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# Nuts & Volts

August 2005

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## TAKING THE TEETH OUT OF BLUETOOTH PHRACKING



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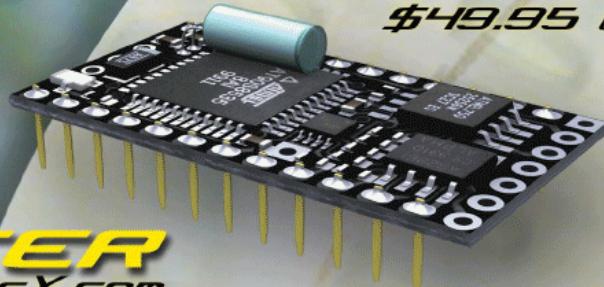
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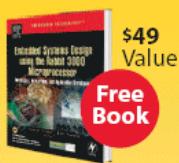
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Solutions That Work

# Nuts & Volts

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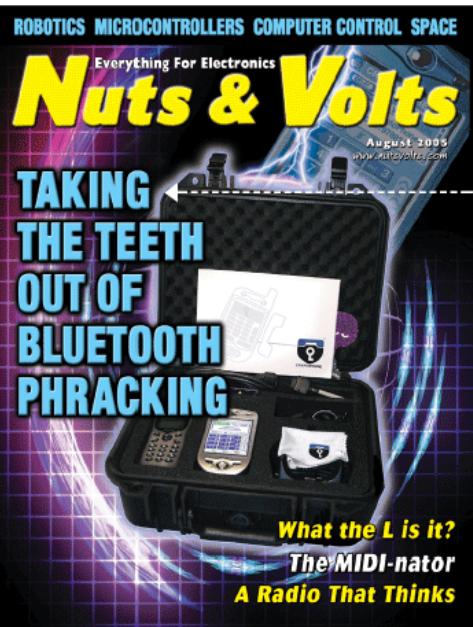
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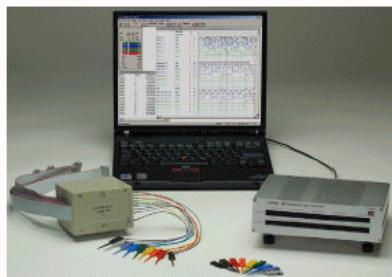


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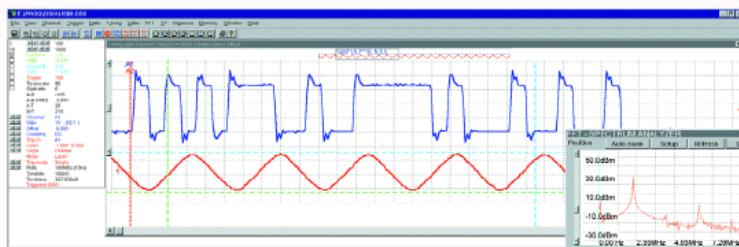
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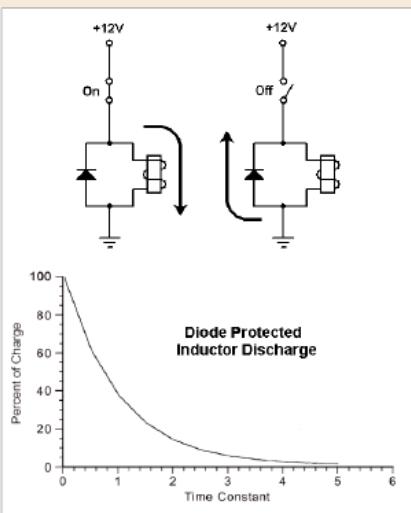
# Reader Feedback

Dear Nuts & Volts:

I just read TJ Byers answer to "Relay Diodes Explained" in the July 2005 issue. I agree with his discussion, except for the equation for  $t$ . One time constant  $-t-$  is equal to  $RC$  in an  $RC$  circuit, but is  $L/R$  in an  $RL$  circuit. It still takes five time constants to fully charge, but you'll get quite a math error the way it was explained.

**Ron Tinckham, Coordinator  
Biomedical Engineering Technology  
Santa Fe Community College**

*Author's Response: Thanks for spotting this oversight. Here is a corrected diagram. — TJ Byers*



Dear Nuts & Volts:

The article "The Field Effect Transistor" in the July issue was a good introduction to FETs and, in my opinion, easy to understand. Good stuff. But there appears to be an error in Figure 5.

The Source and Drain connections for the upper P-channel transistor should be reversed. For a P-channel device, conventional "ON" channel current should flow from Source to Drain and Drain voltage will be negative, with respect to Source voltage.

**Ernie Worley  
Stone Mountain, GA**

*Author's Response: Thanks for correcting the error. In Figure 5, the upper transistor should have its topmost electrode marked S, and its electrode that is connected to*

*the upper output wire should be marked D.*

*In addition, there is a typo mistake in the article. On page 74, it says "... /1KW ..." but that should have been a Greek letter omega, instead of the W. (I should have known better than to try to email a Greek letter!) Anyhow, I should have said "... /1,000 ohms ..."*

*Also, on page 74, my article has "20V/1KW" but the W once again should have been a Greek letter omega. My email program accidentally changed it so it looks like Watts. It should be "20V/ 1,000 ohms."*

Dan Shanefield

Dear Nuts & Volts:

I received the June issue of *Nuts & Volts* and was perusing the Reader Feedback column when I noticed the letter from Mr. Jerry Nicholson, asking why waste someone's time building a strobe flash unit for stop action photography when so many units are widely available from commercial vendors?

I think I speak for a good many of your subscribers when I say: "What would be the fun in that?"

Apparently, Mr. Nicholson has missed the fact that *Nuts & Volts* is, primarily, a publication devoted to hobby electronics, though I have noted there are quite a few professional engineers and technicians who are also sub-

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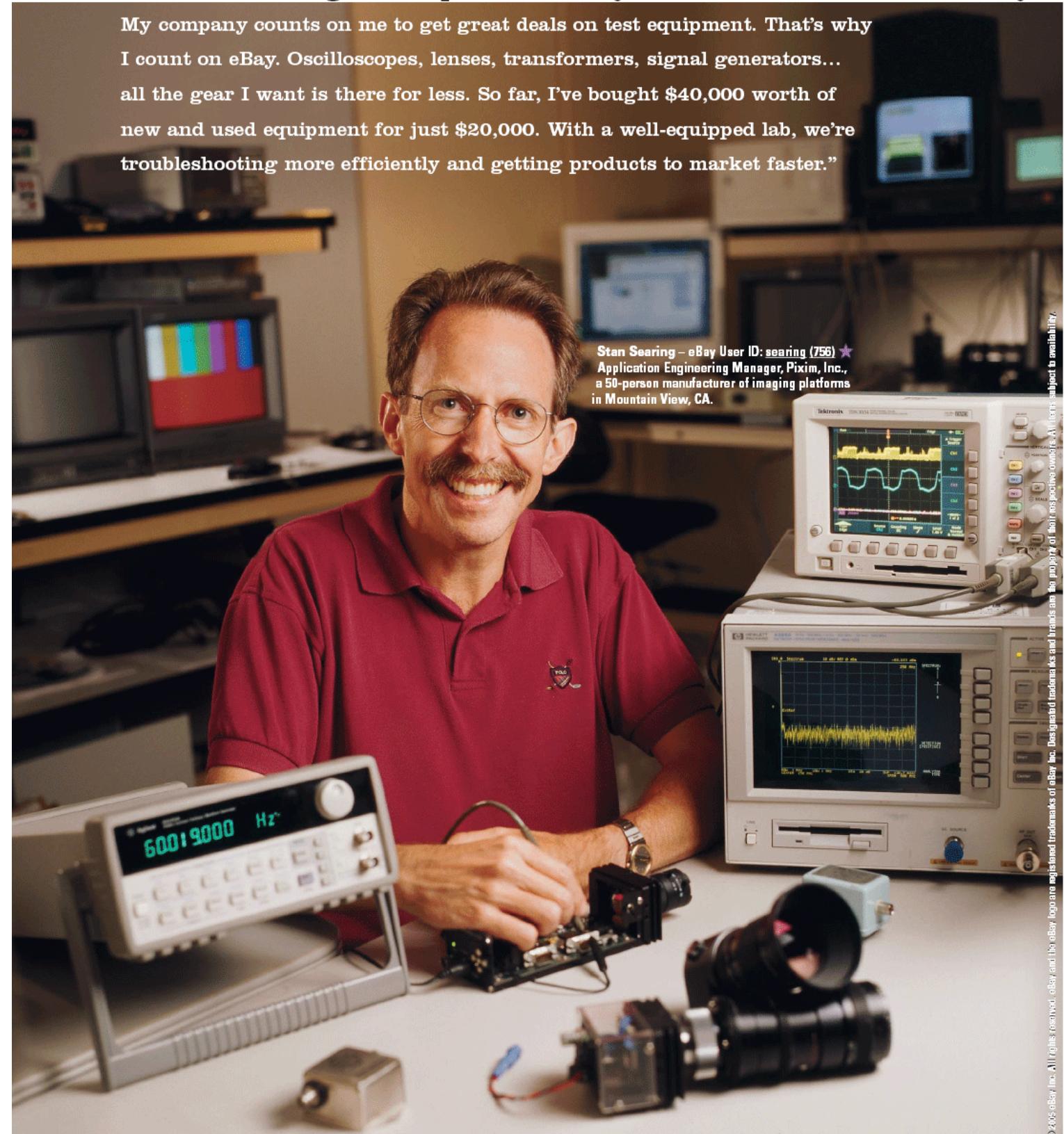


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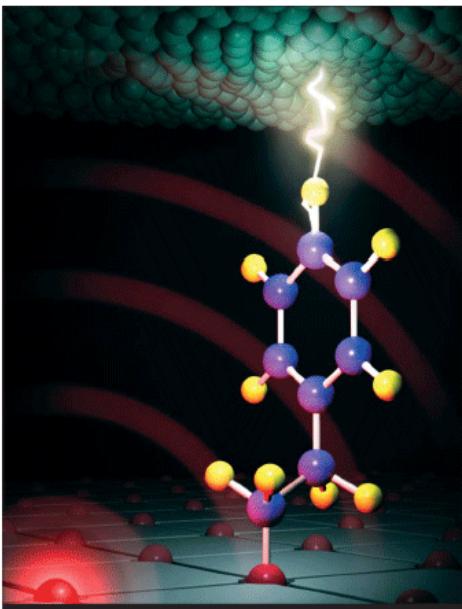
Events, Advances, and News  
From the Electronics World

If you see anything revolutionary and interesting — or just plain cool — while surfing newsgroups, filtering press releases, or simply doing your job, drop me a line about it. Have questions or comments about what you read here in "Techknowledgey 2005?" Send those my way, too. You can reach me at [www.jkeckert.com](http://www.jkeckert.com)

— Jeff Eckert

## Advanced Technologies

### One-Molecule Transistor Unveiled



A single-molecule transistor. Photo courtesy of the National Research Council, Canada.

**A** few weeks ago, the University of Liverpool ([www.liv.ac.uk](http://www.liv.ac.uk)) announced that a scientist from its Surface Science Research Centre has helped create the "world's smallest" transistor by showing that a single molecule can power electric circuits.

Dr. Werner Hofer is among an international team of scientists who have created a prototype that demonstrates that a single charged atom on a silicon surface can regulate the conductivity of a nearby molecule. Computers and other technology based on this concept would require much less energy to power, produce much less heat, and run much faster.

The team tested the transistor potential of a molecule by using the electrostatic field emanating from a single atom to regulate the conductivity of a molecule, allowing an electric current to flow through the molecule. These effects were observed at room temperature, in contrast to earlier molecular experiments that had to be conducted at temperatures close to absolute zero and that achieved much smaller current amplification.

According to Hofer, "Our experiments demonstrate that we can control the current through a single molecule by charging a single atom on a silicon surface, while all surrounding atoms remain neutral. Our research brings us a step nearer to using molecular electronics which would not only prove more efficient and cheaper than current devices, but would also have the potential to power green technology because of the biodegradable nature of the device."

"Our prototype is a scientific breakthrough in molecular electronics. We have successfully shown the potential for devices of unheard-of smallness and unheard-of efficiency. This is the first time anyone has shown that a molecule is in fact a transistor."

## Sniffing Out Lung Cancer

**T**he foremost cause of cancer death among both men and women is lung cancer, but, surprisingly, no specific screening guidelines exist for the disease. X-rays and CT scans often turn up shadows in the chest area, but the shadows aren't necessarily indications of lung cancer. What has been missing is an accurate, cheap, noninvasive detection method.

In a recent study conducted at the Cleveland Clinic ([www.clevelandclinic.org](http://www.clevelandclinic.org)), researchers appear to have come up with a solution. They used the Cyranose electronic sniffer, manufactured by Smiths Detection, Inc. ([www.smithsdetection.com](http://www.smithsdetection.com), formerly Cyrano Sciences, Inc.), to examine the exhalations of 14 lung cancer patients and 45 healthy patients.

The "electronic nose" was programmed to detect certain characteristics in breath and used algorithms to create patterns that were viewable on a computer screen. The researchers found that the pattern characterizing the breath of lung cancer patients was distinctly different from that of healthy patients and of people with other lung diseases.

According to Serpil Erzurum, M.D., chairman of the Department of Pathobiology at the Cleveland Clinic Lerner Research Institute, "Use of the electronic nose could enable physicians to determine the appropriate course for a lung cancer patient's treatment at an earlier stage, rather than after the cancer has spread to other parts of the body and is more difficult to treat. The small, portable nature of the electronic nose also makes it easy to use in physician offices and outpatient settings." At

last report, the device was priced at about \$5,500.00, which is pocket change in the medical industry.

## Computers and Networking

### QuickTransit Derivative to Drive MacTel Machines

By now, you have likely heard that Apple Computer, Inc. ([www.apple.com](http://www.apple.com)), is developing a line of Macs that will retain the Mac OS but use Intel processors instead of the current PowerPC™ chips produced by IBM. But a subsidiary and potentially more interesting rumor is that the new machines will be capable of running a huge range of existing applications that were compiled for non-Intel processors.

This feature is to be provided by a dynamic software translation tool called "Rosetta," which is based on technology from Transitive Corp. ([www.transitive.com](http://www.transitive.com)). Transitive's QuickTransit™ software is already available for Itanium, x86, PowerPC, and Opteron based systems and is shipping as a standard component of the Silicon Graphics Prism™ advanced visualization system. Here, it enables Prism users to take any application that currently operates on SGI® systems that are based on the MIPS® processor and IRIX® operating system and run it transparently on the new Silicon Graphics Prism system, which is based on the Intel® Itanium® 2 processor and Linux® OS.

At least in theory, this approach should eliminate major software compatibility issues between various incarnations of Macs and allow Mac owners to run virtually any off-the-shelf application, regardless of its intended platform.

## XP for Old Clunkers

Addressing a different type of compatibility problem, the word is that Microsoft soon will be introducing a scaled-back version of the Windows XP operating system for users who want to upgrade their software but keep on using hardware that

others have already relegated to the status of doorstops or boat anchors.

The Eiger version isn't really intended for single-computer users but, rather, for institutions with hundreds or thousands of old PCs in operation. It will allow them to upgrade from Windows 95, 98, and NT 4.0, thereby gaining some management features (e.g., Active Directory and Group Policy Management) and access to current security patches. Eiger is also supposed to include Internet Explorer and Windows Media Player.

The minimum system requirements include a Pentium II processor, 128 MB of RAM, and a 500 MB hard drive. If your system doesn't measure up to that level, it may be time to add an anchor rope as your final peripheral and go after a nice steelhead trout.

## Flash to Replace HDs?

Wouldn't it be nice to replace your hard drive with a device that is extremely rugged, has no moving parts, uses 1/20th of the power, and can read and write data at up to 57 and 32 MB/s, respectively? Sure it would, and Flash memory can easily provide that capability. The problem, of course, is that Flash chips tend to

be prohibitively expensive for high-capacity needs.

Nevertheless, Samsung Electronics ([www.samsung.com](http://www.samsung.com)) has announced that it will be selling a new solid-state disk (SSD) product by the time you read this. Word on the street is that the device will be available with capacities ranging from 4 to 16 GB, built on arrays of eight-GB memory chips. Price information was not available at press time, but the SSD is expected to cost perhaps four times as much as a conventional hard drive on a per-byte basis.

However, the devices may find acceptance in military equipment and other applications in which the need to function in a harsh environment outweighs the cost disadvantage. Furthermore, the price of Flash memory is dropping faster than that of hard drives, so they could converge in a few years, thus making hard drive technology obsolete.

## Circuits and Devices Reduced Price on Color Scopes

Agilent Technologies, Inc. ([www.agilent.com](http://www.agilent.com)), recently introduced the DSO3000 series of

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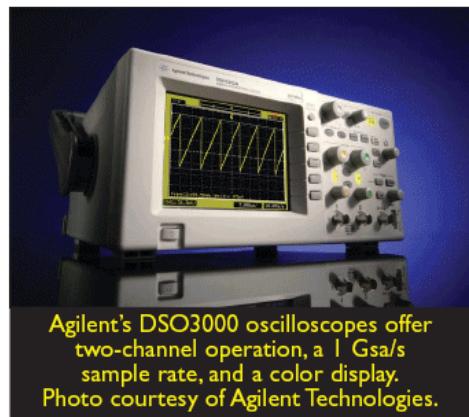


## Engineering Tool

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Agilent's DSO3000 oscilloscopes offer two-channel operation, a 1 Gsa/s sample rate, and a color display.  
Photo courtesy of Agilent Technologies.

economically-priced, portable, digital-storage oscilloscopes (DSOs) with bandwidths from 60 to 200 MHz. The instruments offer two channels and a color display with an expanded waveform viewing area. Designed for engineers and technicians in a variety of industries, as well as educators teaching electronics, the scopes offer a 1 Gsa/s maximum sample rate, 4K memory per channel, and a 5.7" display.

The front panel design looks and operates like a typical portable scope, and an optional software connect package allows for printing and controlling the apparatus via USB. Four models are available as follows: DSO3062A (60 MHz bandwidth, \$995.00), DSO3102A (100 MHz, \$1,295.00), DSO3152A (150 MHz, \$1,595.00), and DSO3202A (200 MHz, \$1,895.00).

## Solar Charge Controller Kit

**B**uilding your own solar power source? You might be interested in the SCC3 12-V solar power controller kit from CirKits ([www.cirkits.com](http://www.cirkits.com)). You get a 20-A system that regulates battery charging from photovoltaic solar panels, providing extended battery life as compared to a direct-connect system.

Applicable to lighting systems, cell phones, radios and small TVs, fans, and other low-voltage DC loads, it can also be fitted with an inverter to produce 110-VAC power. The kit includes a double-sided circuit board, all required components, a schematic

and wiring diagram, and instructions. You just have to provide your own solar panels, batteries, and solder. The kit sells for \$49.95 plus shipping.

## Industry and the Profession Solar Generation Park Opens in Germany



Solar panels in SOLON's Solarpark Gut Erlasse, Arnstein, Germany.  
Photo courtesy of SunPower Corp.

**T**he SunPower Corp. subsidiary of Cypress Semiconductor Corp. ([www.cypress.com](http://www.cypress.com)) recently announced that SOLON AG, Germany's largest solar photovoltaic module manufacturer, has opened phase one of the "world's largest" solar electric plant in Bavaria near Arnstein, Germany.

Solarpark Gut Erlasse, a 12-MW solar electric plant, is located in a working agricultural field. Solar cells from SunPower are components of SOLON's "Mover" power generation system, which is specifically designed for deployment in multi-megawatt solar power plants. Movers automatically tilt and rotate during daylight hours to directly face the sun, thus maximizing energy production.

According to SOLON, the system can generate up to twice the annual energy per square foot of a fixed solar array using conventional solar cells. Over the next five years, the company intends to employ \$300 million worth of SunPower cells. More information about the Mover systems is available at [www.solonmover.com](http://www.solonmover.com) but you will need to understand German to get much out of it.

## 2005 CES was Largest Ever

**A**ccording to a recently released audit, the 2005 Consumer Electronics Show (CES) drew a record 145,868 attendees, including 22,000 international visitors and 40,000 senior-level executives from 110 countries, making it the largest annual trade show in North America. This constitutes a nine percent increase over 2004 and the highest number in the event's 39-year history.

Participants included companies in the audio, accessories, broadcasting, cable, digital imaging, electronic gaming, emerging technology, home networking, home theater, mobile electronics, video, and wireless industries, and exhibits covered 1.5 million square feet of space.

If you missed this year's event, you may want to sign up early for the 2006 CES, which will be held in Las Vegas, NV January 5 through 8. Just navigate to [www.cesweb.org](http://www.cesweb.org) and sign yourself up.

## Sun Buys StorageTek

**I**n the second quarter of 2005, Sun Microsystems ([www.sun.com](http://www.sun.com)) revenues decreased 1.6 percent as compared to the same period in 2004, but profitability improved from a \$125 million loss to \$19 million in the black. Giddy with the pocketful of cash, Sun decided to buy Storage Technology Corporation (StorageTek, [www.storagetek.com](http://www.storagetek.com)) for \$4.1 billion.

StorageTek, which sells tape and disk systems, racked up \$2.2 billion in sales and a net income of \$191 million in 2004. Combined, the new corporate entity will show annual revenues exceeding \$13 billion.

Completion of the merger, which is expected to occur this fall, is subject to regulatory approval, StorageTek shareholder approval, and other customary closing conditions, but if you currently own StorageTek stock, you will be receiving a check for about \$37.00 per share when it occurs. **NV**

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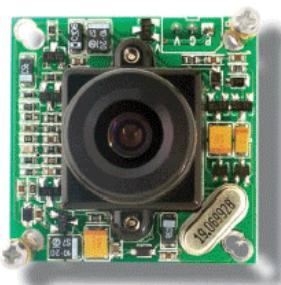
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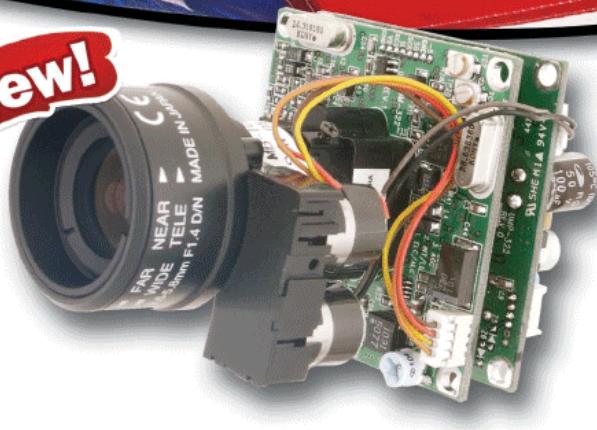
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**MPX-241800**

**\$149.95**

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# Electronics Q&A

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, comments and suggestions.

You can reach me at:

**TJBYERS@aol.com**

## What's Up:

This month focuses on interfaces. There are power supply interfaces that address internal DC resistance, AC resistance, and series diodes. PC sound audio interfaces are also defined. Readers have follow-up suggestions on desoldering/soldering surface-mount ICs.

### Pardon My Impedance

**Q.** How is the internal resistance of a power supply measured and kept at a low value? How important is this?

**Richard H. Abeles**

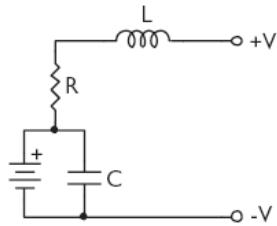
**A.** The internal resistance of a power supply has a lot of influence on the output voltage. A typical power supply — Figure 1 — contains resistance, capacitance, and inductance. The internal resistance is mostly within the wiring of the unit, and while the regulator can react to voltage changes in its immediate vicinity, it can't compensate for voltage drop in the output wires or panel connectors.

All you need to measure the internal resistance of any power source — including batteries — is a DVM and

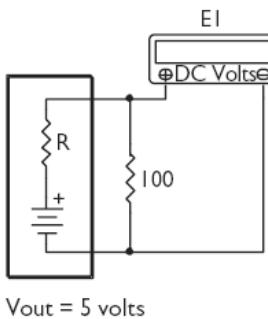
two resistors. The resistors are selected so that they measure the range of the power supply from minimum to maximum. For this example, the values are 10 mA and one amp, respectively. By subtracting E2 from E1, you get the voltage drop across R — the internal resistance. Using Ohm's Law, the value of R is equal to  $E1 - E2 / I2 - I1$ . Let's say the difference is 0.2 volts. Plugging the values in, we get an internal resistance of 200 milliohms. While this may not seem like a lot, it adds up as the output current increases. At five amps, 200 milliohms will consume one volt.

Like I said, this methodology can also be used to test dry cell batteries — even rechargeable. In fact, this is a method often used to measure the amount of charge left in a NiCd or NiMH battery. As the charge decreases, the internal resistance increases.

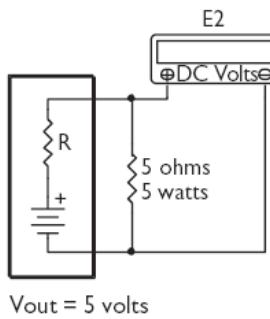
**Figure 1**



### Power Supply Equivalent



$$R = \frac{E1 - E2}{0.99}$$



### Power Supply Internal Resistance

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All laser modules operate from 3 volts and include built in optics providing a parallel beam of 1mr or less. Includes instructions on safety requirements for FDA full compliance

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LM630P3	-3mw	630 nm	10.5x45 mm	.....	\$34.95

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LM650P30	-30mw	650nm	12x51 mm	....	\$249.95

**Green - Class IIIa**

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LM980P30	-30mw	980nm	12X30mm	....	\$49.95

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Laser Diode Visible Red - Class IIIb					



LD630-P10	-10mw	635 nm	5 mm diode	....	\$29.95
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200kV	-200 pfd	3kv .3" x.25"	.....	\$45
270kV	-270 pfd	3kv .3" x.25"	.....	\$45
470kV	-470 pfd	10kv .35" x.25"	.....	\$75
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1.3M/100KV	-1.3mfd	100 kv 6500J case	.....	\$750.00

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28K074	-4kv	15ma 30khz 9-14v 1"cube	.....	\$179.5
28K077	-2kv	10ma 30khz 7-9v .7x1.25	.....	\$9.95
CD25B	-20 kv	trigger pulse 1x1.25	.....	\$169.5
CD45	-40 kv	trigger pulse 1.25x1.25	.....	\$189.5
TRAN103S	-10kv	35ma bal output	.....	\$399.5
FLYLABURN	-10kv	60ma end grd	.....	\$499.5
FLYEXP-4	-4 misc	flybacks	.....	\$249.5
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MINIMAX3	-3kv	10 ma	35 khz	.....	\$199.5
MINIMAX7	-7kv	10 ma	35 khz	.....	\$349.5
SS01S	-1 to 7kvac	for ozone	.....	\$24.95	
GRADIVR10	-7.5kv	15ma 35khz adj	.....	\$79.50	
PVM300	-20kv	25ma 115vac input	.....	\$179.95	

**High Volt DC Modules****12vdc with instructions on how to use.**

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CHARGE10	-10kv	10 kv	.....	\$59.95	
SHK10	-2kv	10 ma	shocker	.....	\$39.95
TRIG10	-20 kv	trigger	shock pulses	.....	\$54.95
SS016S	-+20kv	100ua	.....	\$29.95	
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6.KV.02	-6.5kv	20ma	60hz	float output	.....	\$59.95
9KV.03	-9kv	30ma	60hz	mid grid output	.....	\$79.95
12KV.03	-12kv	30ma	60hz	mid grid output	.....	\$109.95
15KV.03	-15kv	30ma	60hz	mid grid output	.....	\$139.95
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**Spark Gaps and Electrodes**

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SPARK05	-Single gap	1/4" tungsten	.....	\$49.95



TUNG14B	-1/4" x 1"	pair electrodes with holders	tungsten	.....	\$14.95
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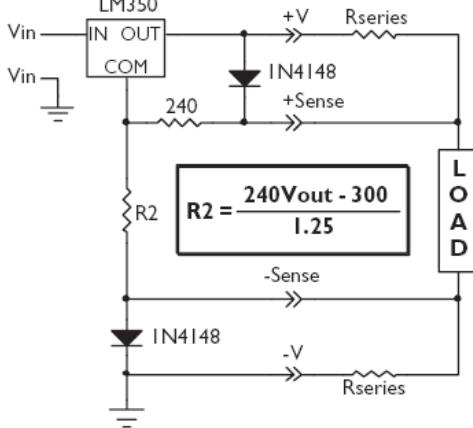
**Toroidal Terminals**

TO8	-8 x 2"	Spun Aluminum Toroid	.....	\$59.95
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TO24	-24 x 6"	Spun Aluminum Toroid	.....	\$399.95
TO30	-30 x 7"	Spun Aluminum Toroid	.....	\$525.95

**See website for more data on above items****Minimum order is \$25.00. Volume pricing available**

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Circle #53 on the Reader Service Card.



**Commercial Power Supply**

**Figure 2**

By keeping tabs on the internal resistance, you're able to interpolate the amount of charge left.

## Eat My Volts

**Q.** I have a problem with my bench power supply in that it doesn't hold the voltage constant. It's a five-volt switching power supply from a reputable company, with specs that say it will provide 25 amps at five volts in the range of 4.75 to 5.25 volts at all temperatures and currents. It doesn't. It varies anywhere between five volts and 3.5 volts. It seems to be worse at high output currents. Do you think the regulator is defective? Can it be fixed easily?

**Johnson**

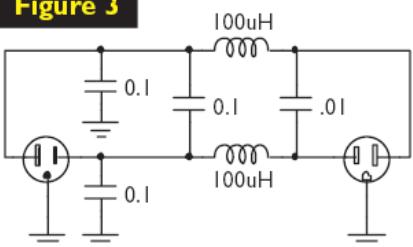
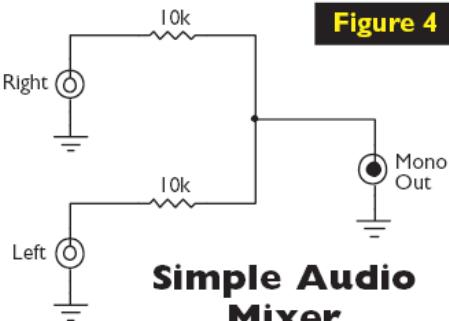
**A.** I doubt the problem is with the power supply itself, but in the way you are using it. If you're like me, I'll attach a couple of clip leads to the power supply's binding post and route the power to the circuit I have on my bench. This is great for experimental purposes where the current is low. But as current increases, the resistance of the wires going from the power supply to your circuit becomes a significant part of the overall design.

Let's say that the power supply is on an upper shelf of your test bench and your project is on the work surface. Scattered about the bench are your test instruments and five feet of #16 gauge wire (very common in

automobile wiring) connecting the power supply to the project. Between the positive and negative runs, the total length is 10 feet, for a total resistance of 40 milliohms (0.04 ohms). At 10 amps, the voltage drop across the wires is 0.4 volts, 0.6 volts at 15 amps, and a hefty one volt at 25 amps. Moreover, if your circuit has switching elements, the input voltage will look like a roller coaster as the currents switch in and out.

The solution is to move the voltage sensing part of the regulator from inside of the power supply to the outside — commonly called remote sensing. It requires four wires (Figure 2): two that provide the real power and two that measure the voltage at the load — after the connecting wires. By doing this, the voltage drop across the power leads is nulled out and the voltage across the load remains constant.

But not all commercial power supplies have voltage sense inputs. Of course, you can try cutting into the circuit board to free these inputs, but you have to do it on a case-by-case basis. Fortunately, you can roll your own using a LM317 or 350 voltage regulator — or any adjustable switching buck/boost IC, for that matter. Simply route the voltage sense points to the load, as shown in Figure 2. Don't be tempted to remove the IN4148 diodes. They prevent the voltage regulator from going postal should the sensor inputs become free floating.

**Figure 3****AC Line Filter****Figure 4**

## Watch Out for Those Spikes

**Q.** I have a power wheel chair, which, not surprisingly, needs frequent recharging. Unfortunately, the battery charger interferes with my radio and TV. Could you send me a circuit that would filter out this interference?

**D. D.**

**A.** I suspect your battery charger uses an off-line switching-mode power supply (SMPS) that's causing spikes on the AC line. The ideal solution is to add a power-factor correction circuit to the charger — but that's far too complicated and would void the warranty. Maybe a hash filter, like the one in Figure 3, might help.

While the circuit is simple, the choice of components isn't. The

impedance of the chokes isn't as critical as the resistance of the coil. Any value between 50 uH and 100 uH will work — as long as the resistance of the coil is 32 milliohms or less. The capacitors, too, are critical. They must be metallized polyester caps with a working voltage of 250 VAC. Don't be tempted to use ceramic capacitors. All components are available from Newark Electronics (800-463-9275; [www.newark.com](http://www.newark.com)). For safety sake, I'd put the circuit into a plastic construction box.

## When East Meets West

**Q.** How can I simply combine the left and right audio signals from a VCR, DVD player, computer sound card, etc., to feed into a mono A/V switch? Could I simply solder the two wires together? I don't see

reduced volume as being a problem with the power amps and big speakers downstream of the switch. I would like to build several of these mixers using parts from my local RadioShack.

**Aaron Duerksen**

**A.** When two outputs are directly wired in parallel, they fight with each other. Most of the time, one of them is trying to push the other to a different voltage, which effectively causes stress and overload on the outputs. At best, you get an uneven mix with lowered output voltage and

increased distortion. You even run the risk of damage to the equipment.

The right way to mix two or more signals is with isolation resistors (Figure 4) — which RadioShack still sells. The value of the resistor should equal the output impedance of the source — typically 10K. The voltage of the mixed signal will be reduced by the ratio of  $ROUT$  to  $RIN$ , where  $ROUT = (RL \times RR) / (RL + RR)$  and  $RIN$  is the input impedance of the mono amplifier. You asked for a stereo mixer, but there is no limit to the number of signals you can mix using this method; simply stack them up, each with its own isolation resistor.

## Don't Bogart That Signal

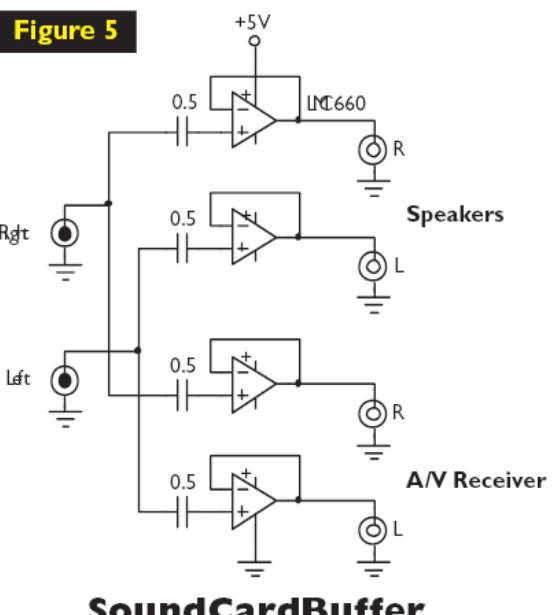
**Q.** I have the audio line out of my computer connected to both computer speakers and a stereo receiver. As a result, the volume of the stereo receiver is lowered severely, and if the computer's output volume is raised to compensate, distortion occurs. Do you have a low-distortion stereo preamp circuit to increase the sound level before it reaches the receiver?

**John S.**

**A.** What you have is a conflict between the impedance of the speakers and the stereo receiver. In other words, the speakers are sucking the life out of the audio signal, leaving little for the receiver input. The way to solve the problem is to put a signal buffer between the sound card and the speakers and receiver, like the circuit in Figure 5. The op-amps are high output devices configured as a voltage follower. This prevents the speakers from loading down the output of the sound card.

## CMOS LED Driver

**Q.** I recently read some place that there is a commonly available CMOS driver for circuits such as the 4027 that would light up an LED. I

**Figure 5****SoundCardBody**

can't find that number and I'm very close to just wiring up a 7555 to do just that and not waste any more time on my search. By not making it be astable, I think it will do the job without any problems.

**Carl Fisher W0HIK**

**A.** I think the chip you're referring to is the 4049 hex inverter. It can provide up to 40 mA of drive current at 15 volts — 5 mA at five volts. When using this gate to drive an LED, you need to use negative logic. That is, a high input will drive the 4049 output low. I recommend that configuration because the output of the 4049 isn't symmetrical. It can sink more current than it can source (5 mA versus 1.2 mA at five volts). Figure 6 shows how to wire the 4049 so that the LED goes on when the input is high. The value of the 1K resistor (typical for  $V_{cc} = 5V$ ) is selected using the formula  $R = (V_{cc} - V_{LED}) / I_{LED}$ . See Table 1 for details.

## Diodes in Series

**Q.** I have a bunch of 1N4004 diodes, which have a PIV of 400 volts. Now, if I connect two of them in series, does the PIV become 400V + 400V = 800V?

**M. John**

**A.** Yep — but with some qualification. Like all things electric, every device is made up of resistance, capacitance, and inductance. In a reverse-biased diode, the two dominant elements are leakage resistance and junction capacitance. The leakage resistance effectively acts like a voltage divider — and unless the leakage current of the diodes are exactly matched, there will be more voltage drop across one diode than the other.

The leakage current of a 1N4004 ranges from 0.05 mA to 1.0 mA, which translates to a resistance of 8,000 megohms to 400 megohms at 400 volts. Let's say that one diode has a leakage current of 0.10 mA and the

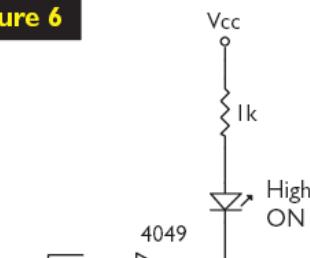
LED Color	V <sub>LED</sub>	4049 Output Current	
Red	1.2V	5V	5 mA
Green	1.5V	10V	12 mA
White	3.5V	15V	40 mA

**Table 1. LED Driver**

other has a leakage current of 0.15 mA. Their equivalent leakage resistance is 4,000 megohms and 2,667 megohms, respectively. This means that the first diode sees 480 volts and the second diode sees 320 volts — not so cool.

When you add in the unequal junction capacitive reactance of the two diodes, the disparity becomes even greater. Unless the diodes are perfectly matched in both respects, I wouldn't use the stacked diodes beyond about three-fourths of their additive voltages: 600 volts for the 1N4004 pair. A solution to using unmatched diodes to their fullest

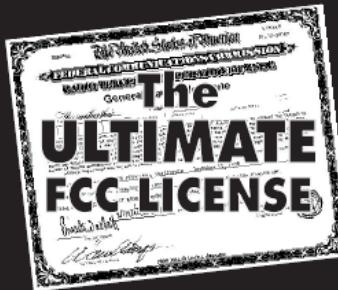
**Figure 6**



**LED Driver**

potential is to place a high-value resistor in parallel with each diode (Figure 7).

In this situation, a 10-megohm resistor will equalize the voltage across the diodes and give them an equivalent PIV (peak inverse voltage) of 800 volts. Oh, don't forget that each series diode drops an additional 0.7 volts. Two in series has a forward voltage drop of 1.4 volts, three equals 2.1 volts, etc.



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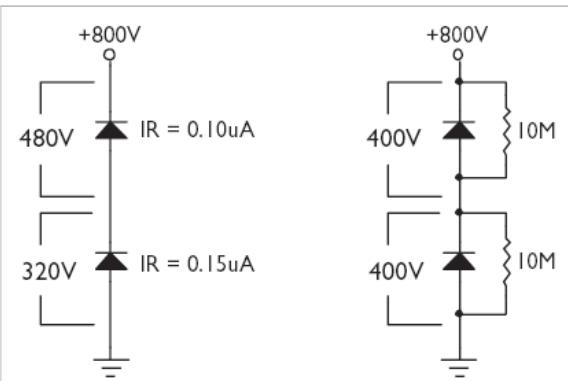
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**Figure 7**    **Diodes In Series**

## Voice Filter

**Q.** I'm looking for a simple circuit, preferably passive, that could filter line-level audio going into the AUX input of a PC sound card. I would like to capture a person speaking and digitize the audio at 16 kbytes/sec in order to keep the file size smaller. However, I get distortion at frequencies above 8 kHz. I believe I need a low-pass filter that would cutoff at 8 kHz.

**Dave Weber**

**A.** What you want is a speech filter — essentially a bandpass filter with cut-off frequencies of 300 Hz and 3 kHz. This is usually done using a Sallen-Key filter configuration, shown in Figure 8. The

solution, you can try removing the op-amps and concatenating the filters, but don't expect miracles.

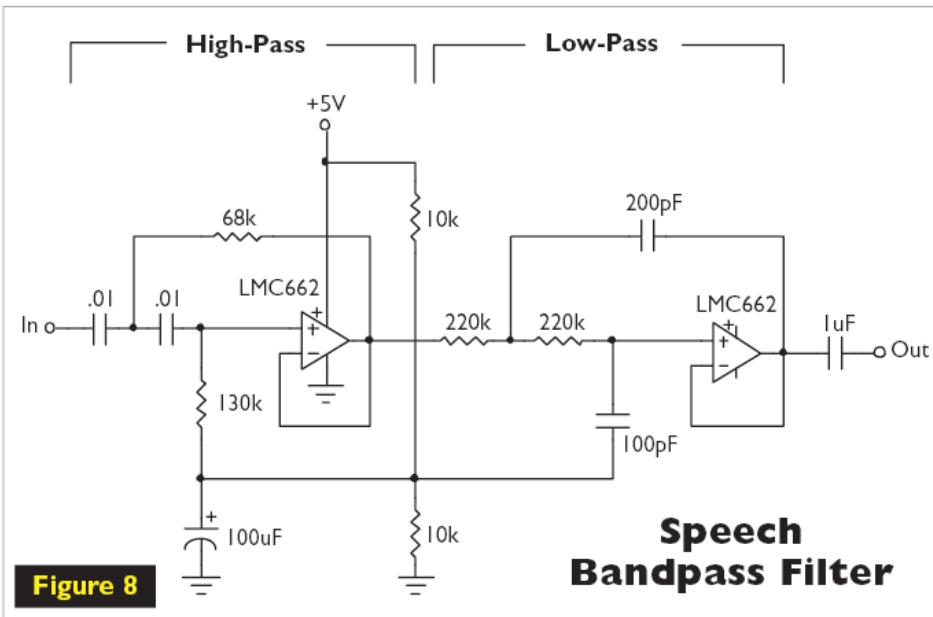
## MAILBAG

Dear TJ,

I was just looking through the April 2005 issue and read your "Un-solder Solder" response. Several weeks ago, I came across a cheap way of doing simple reflow work and I'd like to share it with you. Find it at "Under \$20.00 (USD) Air-Pencil Soldering Iron" at [www.usbmicro.com/odn/documents/46.html](http://www.usbmicro.com/odn/documents/46.html)

**James Bailey**

**Response:** For resoldering those new chips, you might want to check out [www.chipquik.com](http://www.chipquik.com).



[com/newsletters/cq\\_new\\_apr\\_2005.htm](http://com/newsletters/cq_new_apr_2005.htm) – TJ

Dear TJ,

This might help Dave from Reno, NV (desoldering, April 2005). Here's what you need to do the removal:

- A small diagonal cutter and/or Xacto with a new blade
- A low wattage pencil iron with the smallest tip you can get
- Flux — we made our own: a mixture of alcohol & rosin

**1.** With the Xacto blade, cut the chip leads either at the chip or at the PCB, whichever is easier.

**2.** After the chip is off the PCB, flux all the remaining leads.

**3.** Gently apply the tip of the soldering iron, in a sliding motion down the lead. A dental pick will help to ease the lead off the board.

**4.** Wash the PCB with alcohol then with warm soapy water; rinse with clear water and let dry.

At my job, we have temperature-regulated equipment to do this job. At home, I've been using this method for many years with great results. Hope this helps.

**Bob J**

## Cool Websites!

If you wish for a graphics program that's better than Microsoft's Paint but don't want to pay the price for PaintShop or PhotoPaint, check out Paint.NET from the folks at Washington State University. It's free.

[www.eecs.wsu.edu/paint.net/](http://www.eecs.wsu.edu/paint.net/)

Keep up to date on hurricanes — past, present, and future.

<http://link.abpi.net/l.php?20050606A3>

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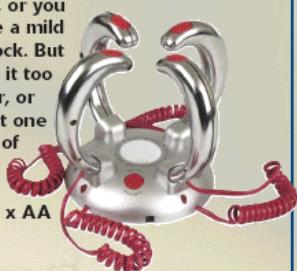
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#### 3 Stage FM Transmitter Kit

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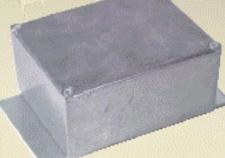


#### Universal High Energy Ignition Kit

KC-5247 \$37.95 + post and packing

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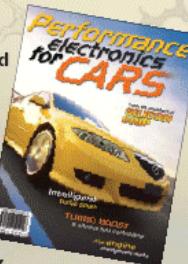
- Works great on points ignition (ie. older cars). Can be used on newer cars with Hall-effect sensor.



#### Performance Electronics for Cars Book

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Australia's leading electronics magazine, Silicon Chip, has developed a range of projects for performance cars. There are 16 projects in total, ranging from devices for remapping fuel curves, to nitrous controllers, and more! The book includes all instructions, component lists, colour pictures, and circuit layouts. There are also chapters on engine management, advanced systems, DIY modifications, and more. Over 150 pages! All of the projects described are available in kit form, exclusively from Jaycar. Check out our website for all the details.



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# Stamp Applications

## A BS2px ADC Trick and a BS1 Controller Treat

*I love to travel. Yes, it has its inconveniences, but every time I feel the power of the jet I'm seated in lift off the runway, a smile crosses my face. The downside of travel is, of course, living without the conveniences of home. For me that includes my stock of electronic parts for experimenting. I do carry a few things when I travel, but just enough to keep me entertained and keep the good folks at the TSA from getting nervous when they inspect my bags. So, as I sit here in my hotel room, I have my trusty PDB, a shiny new BS2px module, and the ubiquitous photocell. Let's see what we can cook up, shall we?*

The BS2px is the latest edition to the BASIC Stamp microcontroller line. In addition to increased speed, the BS2px adds two new commands that give the programmer access to features available in the core SX microcontroller: **CONFIGPIN** and **COMPARE**.

**CONFIGPIN** is somewhat similar to manipulating the DIRS register in that it configures I/O pins, but it has four independent modes that allow for advanced pin behavior.

**CONFIGPIN** mode 0 (SCHMITT) sets the I/O pin to Schmitt trigger mode, causing hysteresis to be added to the inputs. This can be very useful if the input of a pin is a bit noisy and hovering around the normal TTL (1.4 volt) or CMOS (2.5 volt – see below) threshold level. When set to Schmitt mode, a pin will transition from 0-to-1 when it

crosses above about 85% of Vdd, or about 4.25 volts. A pin will transition from 1-to-0 when it crosses below about 15% of Vdd, or about 0.75 volts.

Here's how we can set P15 as a Schmitt trigger input:

```
CONFIGPIN SCHMITT, %1000000000000000
```

How might we use this mode? Well, one thing we could do with it is clean up slow-rising or falling waveforms. Combined with **COUNT** or **PULSIN**, one could measure the frequency of a sine wave input. (Note: *Make sure the input to the pin does not go below Vss.*)

**CONFIGPIN** mode 1 (THRESHOLD) sets the pin input threshold. On reset, all pins are configured for TTL threshold level 1.4 volts. We can raise this up to 2.5 volts (50% of Vdd) by configuring the pins as CMOS inputs. Note that the CMOS threshold will change the behavior of some commands. **RCTIME**, for example, will return a smaller value when using the "standard" circuit and measuring while a pin is high because the span between five volts and 2.5 volts (CMOS) is smaller than the span between five volts and 1.4 volts (TTL). This can actually be helpful when we have a very large "R" constituent in **RCTIME**.

Run this little program with a standard **RCTIME** circuit (Figure 1) to see the difference between the two modes.

Main:

```
DO
  CONFIGPIN THRESHOLD, %0000000000000000
  GOSUB Read_Pot
  DEBUG CRSRXY, 8, 2, DEC potVal, CLREOL
  CONFIGPIN THRESHOLD, %1000000000000000
  GOSUB Read_Pot
  DEBUG CRSRXY, 8, 3, DEC potVal, CLREOL
```

```
PAUSE 100
LOOP
```

Read\_Pot:

```
HIGH PotPin
PAUSE 1
RCTIME PotPin, 1, potVal
RETURN
```

Figure 1. Standard RCTIME Circuit.

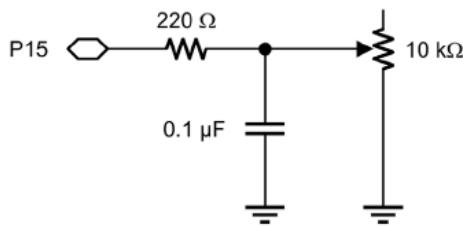


Figure 2 shows the program output. **CONFIGPIN** mode 2 (PULLUP) allows us to enable ~20K pull-up resistors on selected I/O pins. This can simplify external circuit design if we can live with active-low inputs (remember that we can easily make an active-low input look active-high using the invert operator).

Finally, **CONFIGPIN** mode 3 (DIRECTION) sets the pin direction — very much the same as modifying the DIRS register. The following lines of code perform exactly the same function:

```
DIRS = %000000000000001111
CONFIGPIN DIRECTION, %000000000000001111
```

Both lines set pins P0-P3 to outputs; the difference being that the second line only works on the BS2px module.

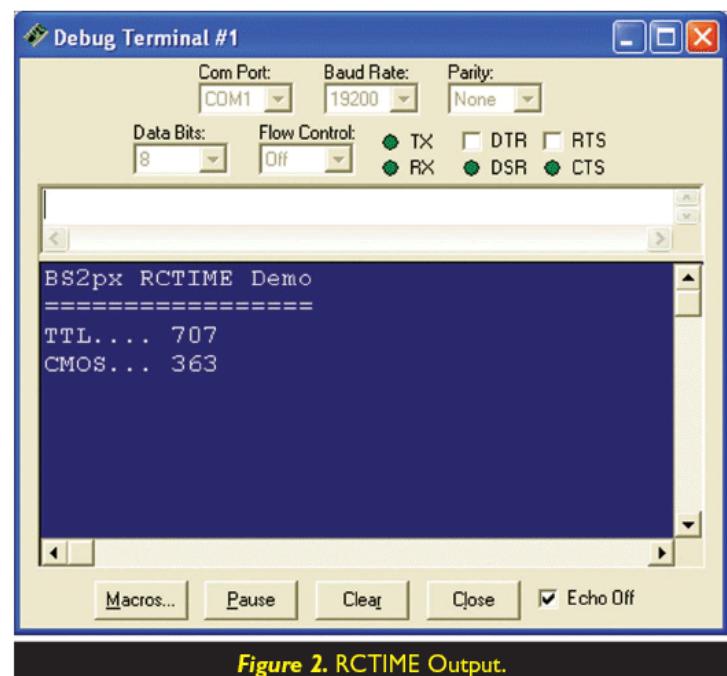
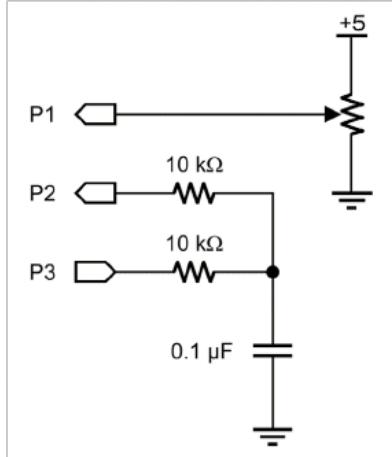
The second new command that the BS2px offers is called **COMPARE**. This allows us to enable and use the onboard comparator. All SX micros have a comparator with inputs on RB.1 and RB.2; these pins map to P1 and P2 on the BS2px. Depending on configuration, the output of the comparator can be routed to RB.0 which maps to BS2px P0.

One of the things that BASIC Stamp users frequently wish for is an ADC — even a simple eight-bit ADC will do in many applications. Well, we can use the BS2px comparator, an additional output pin, and a couple RC components to make one. Really.

In fact, my old pal Scott Edwards (for those of you that are new to *Nuts & Volts*, Scott is the originator of the “Stamp Applications” column) did this using a hardware comparator and the BS1 (see column #25 — available for download from Parallax and from *Nuts & Volts*). The process is actually pretty simple: we will use the **PWM** instruction to generate a voltage (through the RC network) that feeds one side of the comparator. The other side of the comparator will be the input for the voltage we want to measure (0 to 5 volts). When the voltage we generate crosses the level that we’re measuring, we can detect a change in the comparator output and know that we’ve reached the input voltage. Figure 3 shows the connections.

The code is equally simple: the subroutine that measures the input basically “sneaks up” on the input voltage by running a loop until the comparator output says we’ve crossed the input level.

**Figure 3. BS2px ADC Schematic.**

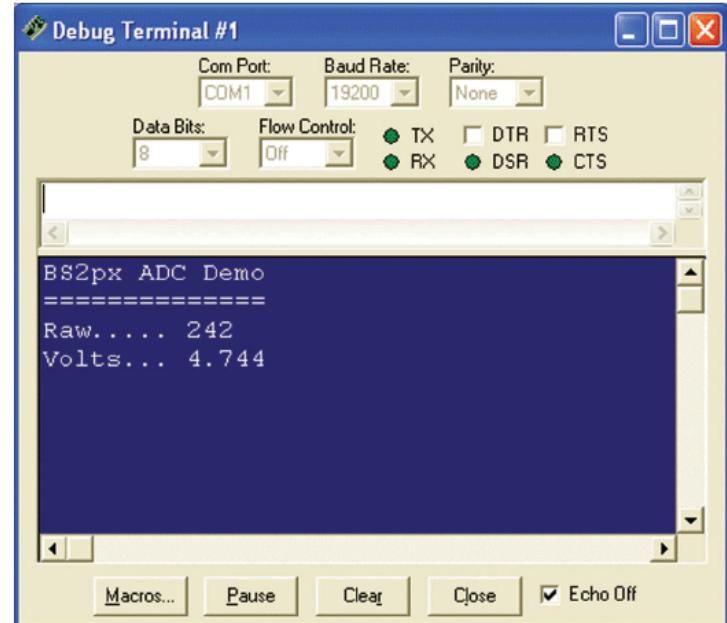


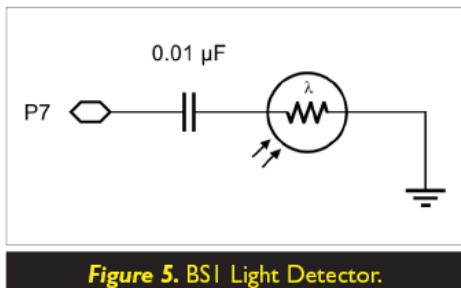
**Figure 2. RCTIME Output.**

```
Get_ADC:
FOR adcVal = 0 TO 255
  PWM DacOut, adcVal, 1
  COMPARE 2, result
  IF (result = 1) THEN EXIT
NEXT
RETURN
```

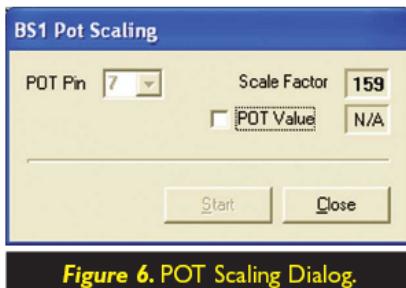
In Scott’s original article, he included another version that used a binary search method to speed up the conversion, but with the speed of the BS2px, it’s not necessary to get that fancy. I did give it a try, but found that it was a bit noisy — perhaps due to components on my PDB. That

**Figure 4. ADC Display.**





**Figure 5.** BS1 Light Detector.



**Figure 6.** POT Scaling Dialog.

said, I never saw any ADC input fluctuations using the subroutine above, so that's what I'm going to stick with.

To fancy things up a bit, though, the main code converts the ADC reading to millivolts. With a five-volt input, each bit is equal to 19.6 millivolts ( $5.00 / 255 = 0.0196$ ). We can use the  $*/$  (star-slash) operator to do the fractional multiplication for us and get the result as shown in Figure 4.

Main:

```

DO
  GOSUB Get_ADC
  mVolts = adcVal * $\frac{1}{\$139B}$ 
  DEBUG CRSRXY, 9, 2,
  DEC adcVal, " ", 
  CRSRXY, 9, 3,
  DEC1 (mVolts / 1000), ".",
  DEC3 mVolts
  PAUSE 100
LOOP

```

So, we end up using as many pins as if we installed the ADC0831, but with fewer parts and fairly simple code. It's a nice trick to have in a pinch.

In this program we're not having P0 track with the comparator output, but it can be done (using mode 1). This is especially useful if we're using pin polling — by configuring P0 as a polled pin, the comparator can cause an action automatically. We could, for example, use **POLLRUN** to switch to another program slot based on a change in the comparator status.

One of the things that I frequently remind my friends to do is have a look at the help file. Please do that — it's the most up-to-date source of information for BASIC Stamp modules. The BS2px is the fastest of the BS2 family, so there are a few commands with syntax changes which may force us to update our programs (notably **SERIN** and **SEROUT**). Remember, conditional compilation is always available and will let us move easily between the BS2px and other BASIC Stamps (except where **CONFIGPIN** and **COMPARE** are used). In fact, both BS2px demos this month have the following bit of code at the top of the program:

```

Check_Stamp:
#IF ($$TAMP <> BS2PX) #THEN
  #ERROR "This program requires the BS2px"
#ENDIF

```

Since **CONFIGPIN** and **COMPARE** are only available on the BS2px, this will cause a dialog that alerts us to

change the Stamp module if we have the wrong type installed.

## Custom Prop Control Made Easy

One of the reasons I'm currently traveling is to work with a group of folks who enjoy building Halloween and other holiday props/displays as a hobby. Interesting

group, if I do say so myself. All kidding aside, I've found the people most steeped in the scary stuff of Halloween to be as "normal" as your next-door neighbor — in fact, they just might be your next-door neighbor, albeit with an interestingly dark hobby.

Some of these folks are new to programming and working with customized controllers, so what my colleague, John Barrowman, and I have been doing is showing them how they can take a general-purpose controller like the BASIC Stamp and make it behave like a purpose-built prop controller (that often costs more money and is fixed at one behavior).

To give you an example, a simple prop timer will wait for an input, create a delay before activating the prop-control output, hold the output on for a period of time, then turn the output off and hold it off for a while so the prop cannot be immediately retriggered. One of the most popular off-the-shelf products that fits this description is called the Universal Dual Timer II (UDT2) by a company called Terror By Design (trust me, Denny and his crew are really nice people, despite the scary company name). The UDT2 is very popular among Halloween prop builders in that all of the timing is set with simple knobs.

One of my recent prop project "show-and-tells" was a light-activated prop controller that works like a digital version of the UDT2. It uses a photocell to measure light as the trigger, and even has a random timing feature that can give a prop more dynamic behavior. Let's build it, shall we?

Since the requirements are so simple, we'll use a BS1 for the prop controller. Start by creating the light sensor circuit shown in Figure 5. Note that the RC circuit for the BS1's **POT** instruction is configured differently than RC circuits used with the BS2's **RCTIME**. The reason for this is that **POT** is actually an active command: it makes the pin an output, charges the capacitor, then actively discharges and checks the capacitor voltage level to do the reading. Stamp Applications column #15 (also written by Scott Edwards) gives a detailed explanation of **POT** versus **RCTIME**. Also note the small value of the capacitor in the circuit; this is necessary due to the very large dark resistance of the CdS photocell.

The thing about **POT** that makes it a bit trickier to use than **RCTIME** is that it requires a calibration constant in the syntax. The purpose of this constant is to scale the resulting RC measurement to a maximum of 255 so that it will fit into a byte (remember, the BS1 doesn't have much

memory). While we could derive the scale value empirically, there's a tool built into the editor that will do it for us.

From the Run menu, select Prop Scaling. This will open a small dialog that lets us set the pin connected to the RC circuit. After that selection is made, click Start and the editor will download a small program to the BS1 (yes, this overwrites the program that was previously there). What we want to do now is adjust the RC circuit for the smallest Scale value.

The way we adjust the CdS photocell circuit is by shielding it from light. Using one of the larger sensors out of a CdS multi-pack from RadioShack®, I found that the Scale value was 159. (Figure 6 shows the POT Scaling dialog.) To test the Scale value, click on the POT Value checkbox and watch the value change as the light falling on the sensor changes. What we'd like to have is a nice range from 0 (very bright) to 255 (dark). Why do we get a small value when the light is bright? Well, a photocell is a light dependent resistor, and the resistance is inversely proportional to the amount of light falling on it.

What we're going to do for the prop controller is monitor the input and when the light falling on the sensor drops (reading goes up), we'll trigger the prop. In this mode, we can detect the presence of a "victim" that blocks the light reaching the photocell.

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The first thing to do is measure the ambient light and set a threshold. Here's how we do it:

```
POT LSense, 159, thresh
thresh = thresh * 12 / 10
```

The **POT** instruction reads the current light level, and then the next line sets the threshold to 120% of that reading. By setting the threshold higher than the original reading, we ensure that a real change is made before the prop trips (we're adding hysteresis to the light detection logic). The nice thing about auto-calibrating in software is that we can recalibrate the prop any time we want simply by resetting the BASIC Stamp module.

With the threshold set, we drop to the main loop of code that waits for the light hitting the sensor to drop.

Main:

```
RANDOM rndVal
POT LSense, 159, light
IF light < thresh THEN Main
```

Notice that the **RANDOM** function is called during this loop too. What this does is stir the Stamp's pseudo-random number generator until we get a trigger level input. This is a great way to add true randomness to a program (since

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we cannot predict when the prop will be triggered).

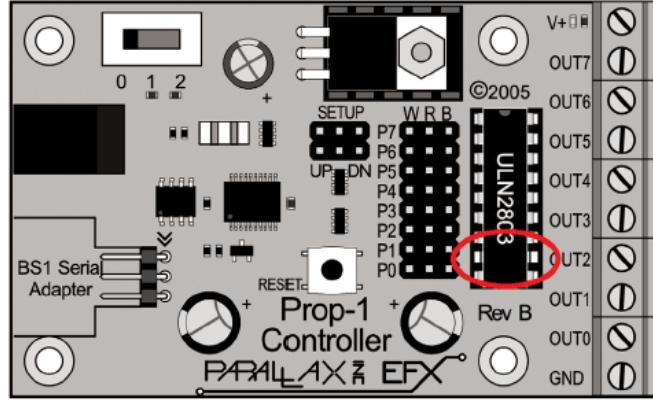
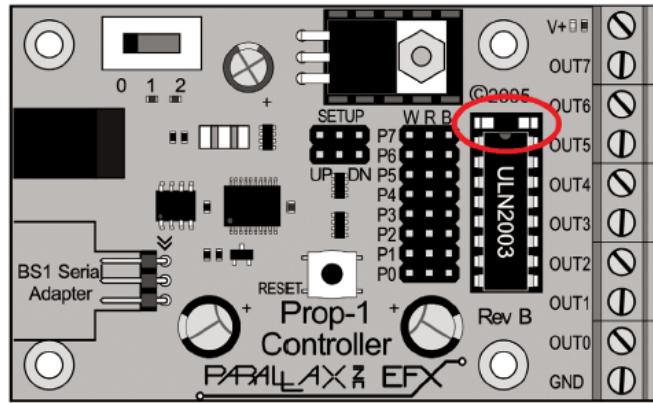
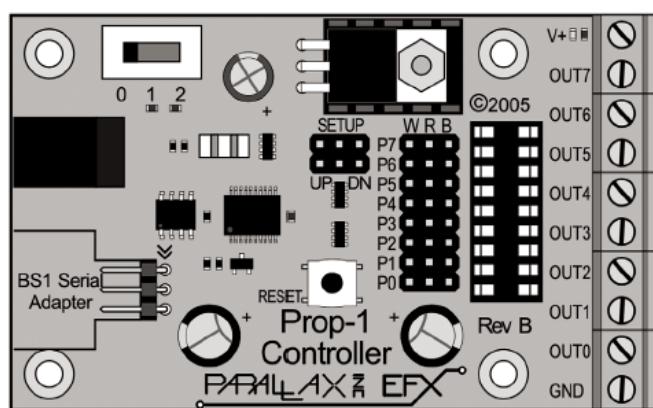
With the prop triggered, the first timing function is the pre-event delay, and this is the time we want to make somewhat random. I say somewhat random because we understandably want the time to fall within a given range.

#### Sequence:

```
mnTimer = DlyMin
mxTimer = DlyMax
GOSUB Random_Timer
```

In order to keep the program easy to maintain, the constants section will hold all the prop timing values. For the pre-event delay, we will use a random time between *DlyMin* and *DlyMax*. Let's drop down to the timing code:

**Figure 7. Prop-1 ULN2x03 Configurations.**



#### Random\_Timer:

```
span = mxTimer - mnTimer + 1
secs = rndVal // span + mnTimer
```

#### Timer:

```
IF secs = 0 THEN Timer_Done
PAUSE 1000
secs = secs - 1
GOTO Timer
```

#### Timer\_Done:

```
RETURN
```

This subroutine actually has two entry points: the top, at *Random\_Timer* randomizes the value of *secs* based on the current value of the random number generator (in *rndVal*) and the values passed in *mnTimer* and *mxTimer*. This code also takes advantage of the modulus (//) operator. By dividing the random value by the span plus one (of our timing extremes) we get a number between zero and the span. When we add the minimum timing value, the result in *secs* will be between those passed in *mnTimer* and *mxTimer*.

Let's work through an example: Perhaps we want a randomized delay between five and 10 seconds. The span is calculated as 10 minus five plus one (six). Since the modulus operator returns the remainder of a division, using six as the divisor will give us a value between zero and five. By adding our minimum value of five, we finally end up with a value between our targets of five and 10.

The value in *secs* is used as a counter for the subroutine entry at *Timer*. This is pretty simple; while *secs* is greater than zero, we will **PAUSE** for one second (1,000 milliseconds), decrement *secs*, and then check it again. When the value of *secs* does reach zero, the subroutine will terminate and we'll return to the main program.

With the randomized timing done, the rest of the prop control sequence is fairly simple.

```
Prop = IsOn
secs = OnTime
GOSUB Timer
Prop = IsOff

secs = OffTime
GOSUB Timer

GOTO Main
```

As you can see, there is nothing mysterious at all about this. We simply activate the prop control output, start the timer, deactivate the prop output, then run the timer for the required down-time before the next possible trigger event.

Let me point out again that the program uses defined symbols so that any changes we want to make all happen in the same place in the code. Here are the constant declarations for the prop timer:

SYMBOL	DlyMin	= 5
SYMBOL	DlyMax	= 15
SYMBOL	OnTime	= 5
SYMBOL	OffTime	= 30

# Stamp

This version of the program uses a timing resolution of one second. In some cases, this may be a bit coarse. If more resolution is required, it's easy enough to change secs to a Word, and update the **PAUSE** statement in the Timer subroutine to 100 milliseconds. Since there's not quite enough variable space left to pass fraction seconds in *mnTimer* and *mxTimer*, we'll also need to add a line to the end of the randomizing section of the timer routine.

```
secs = secs * 10
```

This will correct the value for the increased resolution.

## Using Photocells with the Prop-1 Controller

If you connect the circuit shown in Figure 5 to a Prop-1 controller, you'll find that it doesn't behave as you expect. What gives? Well, all of the I/O pins on the Prop-1 are connected to the input side of a ULN2803 driver — the driver is preventing the **POT** instruction from working properly. We have a few choices to correct this.

The first is the easiest — simply remove the ULN2803 from its socket. This choice is only viable, though, if we're using the TTL outputs from the Prop-1 and have no need for the high-current side (see Figure 7, top diagram).

The second choice is to put the **POT** circuit on P7, and then replace the ULN2803 with a ULN2003. When doing this, the ULN2003 must be inserted such that it is bottom-aligned with the ULN2803 socket. This will open the connection to the P7 circuit (see Figure 7, middle diagram). Note that when using a **POT** circuit on P7 or P6 of the Prop-1 controller, you must remove the input configuration (SETUP) jumper on the pin being used.

Finally, and the least desirable, is to do a bit of "surgery" on the ULN2803. Use this choice only if the first two are not available. Remove the ULN2803 and cut off the input and output legs that correspond to the pin that you'll use. Note that ULN2803 pins 1 and 18 correspond to P7, ULN2803 pins 2 and 17 correspond to P6, and so on. Do not remove ULN2803 pins 9 or 10 — this will prevent the high-current outputs from working properly. The bottom diagram in Figure 7 shows a ULN2803 modified to allow a POT circuit to work on P0. Again, do this only as your last resort, and make sure you have a spare ULN2803 or two before you start "operating."

Okay, I'd say that's about enough from the road. Halloween is just a couple months away — you'd better get busy with those props! Until next time — when I'm home and comfy — Happy Stamping. **NV**

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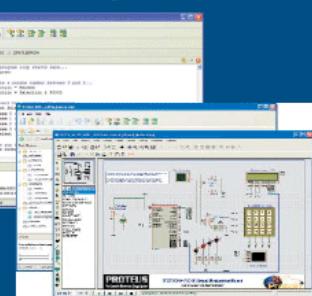
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Our FM100B is the updated version of a truly professional frequency synthesized radio transmitter station in one durable, handsome cabinet. It is used all over the world by serious hobbyists as well as churches, drive-in theaters, and schools. No one else offers all of these features at this price! The included frequency display and audio level meters assist in easy operation. The "B" version now includes some additional functionality including a line level monitor output, improved stereo separation, spectral purity, audio clarity, and adjustable RF Output. An exclusive selectable microphone mixer and auto AGC circuit combines your local mic audio with your music input or mutes the music when mic audio is present. You don't even need an external mixer!

Sound quality is impressive; it rivals commercial stations. Low pass input filtering plus peak limiters put maximum "punch" in your audio, and prevent overmodulation distortion. No wonder everyone finds the FM100B to be the answer to their transmitting needs... you will too! The kit includes a sharp looking metal cabinet, whip antenna, and built-in 110/220 volt AC power supply. An external antenna connection allows hook-up to high performance antennas like our TM100 and FMA200. We also offer a high power export version of the FM100B that's fully assembled with one watt of RF power for miles of program coverage. Many islands and villages use it as their local radio station! The export version can only be shipped outside the USA, or within the US if accompanied by a signed statement that the unit will be exported. (Note: The end user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body).

FM100B	Super-Pro FM Stereo Radio Station Kit, 5uW-25mW	\$269.95
FM100BEX	High Power Version, 5uW-1Watt Output	\$349.95
FM100BWT	High Power Version, 5uW-1Watt, Factory Assembled	\$429.95

### Professional Synthesized AM Radio Transmitter

- ✓ Fully frequency synthesized, no frequency drift!
- ✓ Ideal for schools
- ✓ Microprocessor controlled
- ✓ Simple settings



Run your own radio station! The AM25 operates anywhere within the standard AM broadcast band, and is easily set to any clear channel in your area.

It is widely used by schools - standard output is 100 mW, with range up to 1/4 mile, but is jumper settable for higher output where regulations allow. Broadcast frequency is easily set with dip-switches and is stable without drifting.

The transmitter accepts line level input from CD players, tape decks, etc. Includes matching case & knob set and AC power supply!

AM25	Professional Synthesized AM Radio Transmitter Kit	\$99.95
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### Tunable AM Radio Transmitter

- ✓ Tunes the entire 550-1600 KHz AM band
- ✓ 100 mW output, operates on 9-12 VDC
- ✓ Line level input with RCA connector



A great first kit, and a really neat AM transmitter! Tunable throughout the entire AM broadcast band. 100 mW output for great range! One of the most popular kits for schools and scouts! Includes matching case for a finished look! The AM1 has been the leading Scouting project for years and years. Try out your kit skills and at the same time...get on the air!

AM1C	Tunable AM Radio Transmitter Kit	\$34.95
AC125	110VAC Power Supply for AM1C	\$9.95

### Tru-Match FM Broadcast Antenna

- ✓ Fully weatherproof-rugged PVC construction
- ✓ Matches 50 or 75 ohm systems
- ✓ Tunable for a perfect match over the entire 88-108 MHz FM band
- ✓ 25 watt RF power maximum



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- ✓ DDS and SMT technology!
- ✓ 0 Hz to 5 MHz at 0.1Hz resolution!
- ✓ 0 to 10V peak to peak output level
- ✓ Sine, Square, or Triangle waveform

Following our world famous SG550, we are proud to introduce the SG560, the next generation signal generator!

To begin with we increased the frequency range all the way up to 5MHz and all the way down to 0Hz (yes, we mean zero...or DC!) in continuous 0.1Hz steps across the entire range! Then we gave it a variable output level all the way up to 10V peak to peak in either Sine, Square, or Triangle waveforms! You can also provide a DC offset to the output to recreate TTL, 4000 series logic levels, low voltage logic levels, AC waveforms with a DC component, or just plain AC signals!

SMT and DDS technology is used throughout the SG560 for ultimate performance and reliability. If you're looking for a lab quality sig gen at a super hobbyist price, the brand new SG560 fits the bill...and a whole lot more!

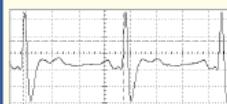
#### SG560WT Audio/RF Signal Generator, Factory Assembled

\$329.95



### Electrocardiogram Heart Monitor

- ✓ Visible & audible display of your heart rhythm
- ✓ Re-usable sensors included!
- ✓ Monitor output for your scope
- ✓ Simple & safe 9V battery operation



Enjoy learning about the inner workings of the heart while at the same time covering the stage-by-stage electronic circuit theory used in the kit to monitor it.

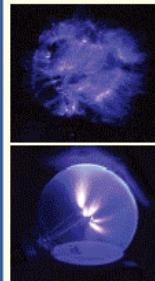
The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors. The fully adjustable gain control on the front panel allows the user to custom tune the differential signal picked up by the probes giving you a perfect reading every time! Multiple "beat" indicators include a bright front panel LED that flashes with each heart beat, an adjustable audio output to hear the beat, and of course, the monitor output to view on a scope, just like in the ER! Operates on a standard (and safe) 9VDC battery. Includes matching case for a great finished look. The ECG1 has become one of our most popular kits with hundreds and hundreds of customers wanting to get "Heart Smart"!

#### ECG1C Electrocardiogram Heart Monitor Kit With Case ECG1WT Factory Assembled & Tested ECG1 ECGP10 Replacement Reusable Probe Patches, 10 Pack

\$44.95  
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\$7.95

### Plasma Generator

- ✓ Generates 2" sparks to a handheld screwdriver!
- ✓ Light fluorescent tubes without wires!
- ✓ Build your own plasma balls!
- ✓ Generate up to 25kV @ 20KHz from a solid state circuit!



This new kit was conceived by one of our engineers who likes to play with things that can generate large, loud sparks, and other frightening devices. The result... the PG13 Plasma Generator designed to provide a startling display of high voltage!

It produces stunning lighting displays, drawing big sparks, to perform lots of high voltage experiments. In the picture, we took a regular clear "Decora" style light bulb and connected it to the PG13 - WOW! A storm of sparks, light tracers and plasma filled the bulb. Holding your hand on the bulb doesn't hurt a bit and you can control the discharge! It can also be used for powering other experiments; let your imagination be your guide! Can also be run from 5-24VDC so the output voltage can be directly adjusted.

#### PG13 Plasma Generator Kit PS21 110VAC input, 16VAC output power supply

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LLS1 Laser Light Kit \$44.95

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TFM3C Tri-Field Meter Kit \$64.95

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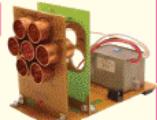


One of our most popular science fair projects! Sensitive doppler shift radar provides a digital readout in either Km/Hr, Mph/Hr, or Feet/Sec! Features an 1/8th mile range for average size vehicles. Actual doppler shift can be monitored with the built-in earphone jack. Includes the nifty case set shown, and runs on 12VDC. Uses two standard coffee cans (not provided), so start drinking up!

SG7 Speed Radar Kit \$59.95

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The Latest in Networking and Wireless Technologies

# Open Communication

## A Radio That Thinks — An Introductory Look at Software-Defined/Cognitive Radio

**T**hose of you who follow electronics either as a career or hobby know that over the past years, electronics has evolved from an all analog world to a mostly digital world. Most electronic products today incorporate digital techniques. And in fact, it is hard to name a modern electronic product that does NOT contain a single chip computer called an embedded controller that runs the show.

Yet, analog has not disappeared completely. It won't ever go away because all physical phenomena in nature are analog. Voice and music are analog, video is analog, and most signals from sensors and transducers are analog. Yet despite all this natural "analogness," so much of it has already become digital. Music CDs and MP3 players are digital. The new high definition TVs are digital. Cameras are digital. And so it goes.

Now, the final frontier of electronics, radio — or wireless as we call it again today — is now going digital.

Cell phones are now mostly digital. Satellite and High Definition AM/FM radio is all digital. This rampant conversion is happening right now, but thanks to some breakthroughs and continuously improving integrated circuits, the digitization of radio is on the fast track.

One term for it is software-defined radio (SDR). Not only is the radio going digital, but it is becoming software, programs that run on a digital computer, or processor. My column this month is to introduce you to SDR and the new companion technology cognitive radio.

### DSP to the Core

The core technology in SDR and cognitive radio is digital signal processing (DSP). DSP is the computer equivalent of analog signal processing. All radios process signals from antenna to speaker and from microphone back to the antenna. Those processes have in the past been purely analog.

Typical familiar analog processes are amplification, filtering, up/down conversion, mixing, equalization, compression, modulation and demodulation, encoding and decoding, and so on. Today, much of this is done digitally.

In a nut shell, a digital version of the analog signal is fed to a fast microprocessor along with a special

program written to perform one of the analog functions mentioned above. The new digital output of that process is then converted back to analog. And the results are similar to what you would expect from an analog circuit. And no one can tell the difference.

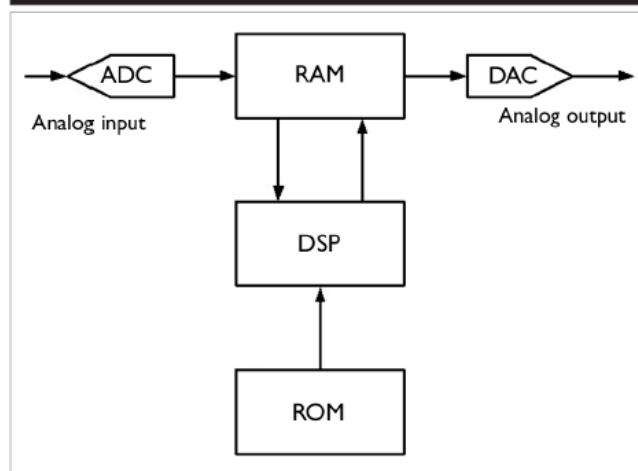
Figure 1 shows a simplified block diagram of a digital signal processor. The analog signal is applied to a fast analog-to-digital converter (ADC). This device digitizes the analog signal into a stream of binary words that represent the analog voltage variations. Remember, to capture the full content of the analog signal, the sampling and digitization rate has to be at least twice the highest frequency in the analog signal.

For example, to convert analog audio with frequencies to 20 kHz into digital, the sampling rate has to be no less than two times that or 40 kilo samples per second (KSPS). You may already know that CD audio is sampled at 44.1 KSPS. That is a sample every 22.675 microseconds. A 4.2 MHz video signal needs a converter that will sample at 8.4 mega samples per second (MSPS) or faster. A 10 MSPS rate would work well or one sample every 100 nanoseconds.

To do radio, we need ADCs that can sample at many hundreds of MHz. Current ADC technology easily converts signal at frequencies up to about 250 MHz. And the technology is continually improving. A New York company called Hypres uses a cryo-cooled (< 4 degrees Kelvin!!) ADC that can sample at well over 1 GHz.

The stream of binary words from

**Figure 1.** Digital Signal Processor block diagram.



the ADC goes into a random access (read/write) memory (RAM). The digital signal processor (DSP) is a specially designed microprocessor that has been optimized for DSP.

For example, it uses two memories rather than just one, a high speed RAM for the data, and a read-only memory (ROM) where the programs are stored. This is called Harvard architecture. The DSP also has special hardware and instructions that implement a multiple and accumulate (MAC) operation that is central to all DSP.

All signal processing — analog or digital — can be expressed as mathematical equations. To process the data, all you have to do is implement a computer that will solve that equation. One or more programs in the ROM implement mathematical algorithms that define how the digital data in the RAM is to be processed. It could be an algorithm that describes a band pass filter, a spectrum analysis, or modulation.

The DSP processes the data and generates a new stream of binary words that represent the process output. It is also stored in RAM. Finally, that new RAM data is converted back to digital by a fast digital-to-analog converter (DAC). The result is a processed analog signal that cannot be distinguished from that processed in traditional analog circuits.

Most of you who are unfamiliar with DSP are probably wondering why in the world would we go to so much complexity and expense to replace some relatively simple analog circuits with a mega-complicated digital computer. The main answer is probably, "just because we can." Lots of things in electronics are like that.

For example, who really needs 3 GHz personal computers? Anyway, the ADCs, DACs, and DSP chips are now fast enough and cheap enough so that they can be used virtually anywhere today. And overall, they will take up less space and use less power than their analog predecessors. And they require no adjustment or calibration.

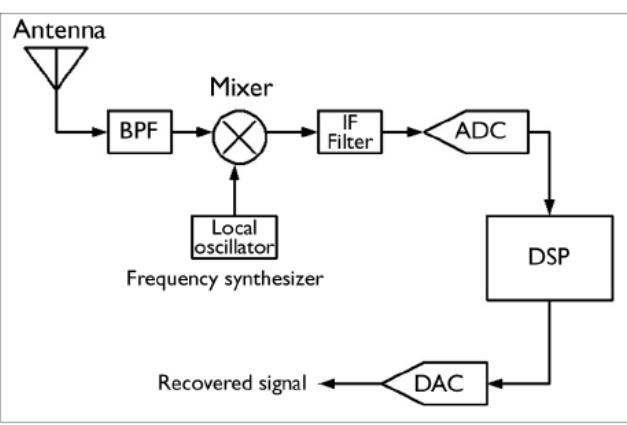
A really key benefit of DSP is that you can achieve some processing results that essentially cannot be done easily or at all in analog. Filters with super sharp selectivity and the desired phase response are really easy to implement in DSP. And with DSP, performance levels can easily exceed anything you can get with an analog filter.

Another good example is a spectrum analysis. Using the fast Fourier transform (FFT) — a popular mathematical algorithm — you can easily look at a sampled analog signal and output a Fourier analysis that tells the individual sine wave frequencies and amplitudes of the entire content.

The hottest and fastest growing wireless technology called orthogonal frequency division multiplexing (OFDM) can only be done with DSP. Finally, the digital output is fully compatible with the inputs and outputs of products today. Most products are already digital such as cell phones, MP3 players, even the new HDTVs.

One of the best examples of how DSP has changed communications products is the modem. The early PC modems were large plug-in cards with ICs, filters, and all manner of analog circuits. Today, a modem is implemented fully in a single DSP chip. All filtering, modulation/demodulation, etc., is done in a tiny DSP.

The actual digital signal processing is usually accomplished by a specialized microprocessor optimized for this type of work. However, there are other ways to do it. For example, any digital computer or microprocessor can be programmed to do DSP. However, it must be fast enough.



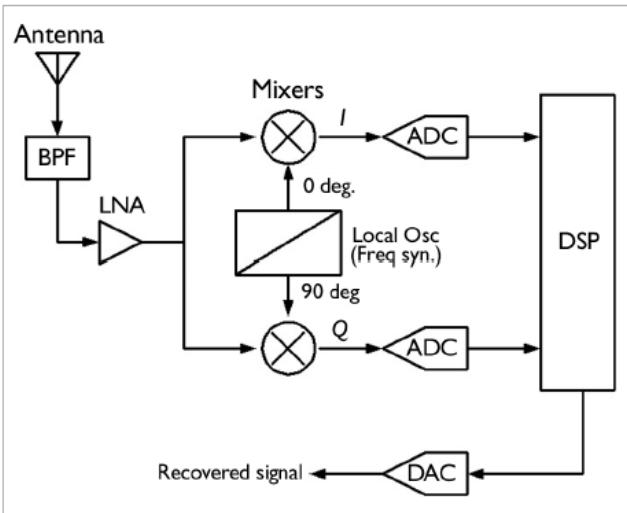
**Figure 2.** Standard superheterodyne receiver design of software-defined radio.

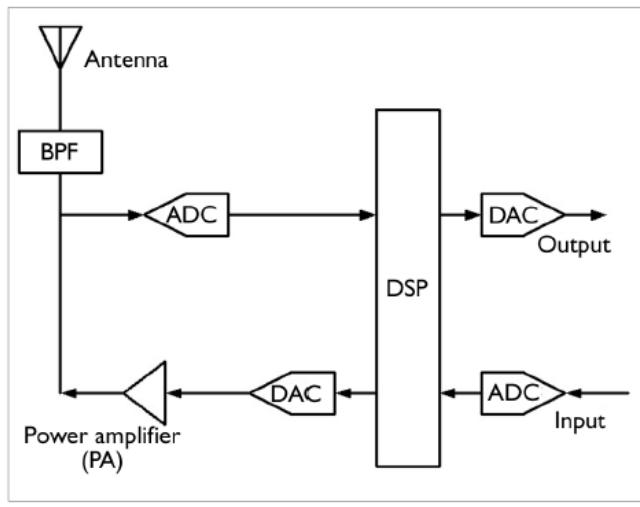
If the signals to be processed are very low frequency, then a PC or standard embedded controller can do it. For high frequency signals like radio waves, your processor needs to be super fast so processing can take place in real time. In some cases, the speeds are so great even a fast DSP can't keep up. In such cases, a programmable logic device (PLD) — such as a fast field programmable gate array (FPGA) — can be used.

## Software-Defined Radio

A software-defined radio (SDR) is one in which some or all signal processing functions are done on a DSP in software. The most common software radio today uses a standard

**Figure 3.** Receiver that works with both FM and PM forms of modulation.





**Figure 4.** Radio made with DSP.

superheterodyne receiver design where the incoming signal from the antenna is fed to a band pass filter to select the signal frequency, then to a low noise amplifier (LNA). See Figure 2.

The amplified signal then goes to a mixer along with the sine wave from a local oscillator (LO), usually a frequency synthesizer. The mixer output is the difference between the input signal frequency and the LO frequency. This process is called down conversion since the output is a lower intermediate frequency (IF). Good selectivity is easier to obtain at lower frequencies. Crystal, ceramic, or surface acoustic wave (SAW) filters are the most commonly used IF filters.

At the IF output, the signal is fed to the ADC for conversion to digital. From there, a DSP does all other operations such as additional down conversion, filtering, demodulation, and other functions called for. The resulting processed signal is then converted back to analog in a DAC, then fed to a power amplifier and speaker.

In some designs, the mixer translates down directly to the original modulating (baseband) signal. This is called direct conversion. It works well and allows the DSP to provide the filtering. However, this technique works only for AM signals including SSB. To handle FM or PM forms of modula-

tion, another method is needed. Most communications products today use some digital form of phase or frequency modulation (BPSK, QAM, FSK, etc).

Figure 3 shows a receiver that works with FM and PM. The signal is first filtered with a band pass filter, then amplified in a low noise RF amplifier (LNA). The resulting signal is applied to two mixers.

Also applied to the mixers are signals from the local oscillator usually a frequency synthesizer. The two LO signals are 90 degrees out-of-phase with one another. We call these signals in-quadrature.

The mixer outputs are called the in-phase (I) signal and the quadrature (Q) signal. The LO frequency is set to the incoming signal so this is a direct conversion receiver. The I and Q signals both contain the original information but there is a 90 degree shift between them. Both signals are digitized by identical ADCs. The ADC outputs are put in RAM as before. With both the I and Q versions of the signal, the DSP can perform the demodulation and other processing. Virtually all cell phones today use some form of this arrangement in their receiver.

In a SDR transmitter, the opposite process is implemented. The voice to be transmitted is first digitized by an ADC then encoded to compress it so that it can be transmitted at a lower rate that consumes less bandwidth. The digitally encoded signal is then converted by the DSP into signals that implement the desired modulation like FSK or QPSK.

The DSP outputs both I and Q versions of the signal. These I and Q signals are fed to mixers with a quadrature LO and up converted to the desired output frequency. The result-

ing composite signal is then sent to a power amplifier (PA) and then the antenna.

The ultimate goal of SDR is to do all processing digitally. To do this, we have to eliminate the mixers. The mixers do translate the high radio frequencies down to an IF that can be digitized by commercial ADCs. You can buy 12- and 14-bit ADCs that will sample at up to about 250 MSPS. That is pretty fast, but not for all radios.

Most modern radios operate in the microwave region ( $> 1$  GHz). ADCs that sample that fast are not commonly available. However, if the radio frequencies are fully below about 100 MHz, you can make the entire radio with the DSP. It would look like that shown in Figure 4.

You still need a band pass filter to somewhat narrow the receive/transmit frequency range and you still need an LNA to get the signal strength up to a level that can be used by the ADC. In the transmitter, you still need an external power amplifier. But other than that, all other processing like filtering, modulation/demodulation, whatever is handled by the DSP. For example, you could easily do an entire AM broadcast band radio in a DSP.

The most current widespread use of SDR as described in Figure 3 is in cell phone base stations. Base stations must support current digital technology cell phones (GSM, CDMA), as well as older analog and digital systems (AMPS, TDMA). This is still done by using multiple radios. But with a single SDR, the entire cell phone spectrum is digitized and DSP used to separate out the different signals with different modulation schemes and encoding.

A forthcoming SDR application is the military's Joint Tactical Radio System (JTRS). This is an attempt by the military to create a general-purpose radio that can serve all of the services regardless of the modulation and coding systems used. It will prevent military personnel from having to fiddle with frequencies,

modes of operation, and other technical aspects, and concentrate on the communications itself which is always critical in battle and non-battle situations.

## Cognitive Radio

All radios today operate in a fixed frequency spectrum with specific modulation, multiplexing, encoding, and data protocols. If two radios are to communicate, they must be identical in those technical specifications. If not, they will not talk to one another, that is interoperate. This works okay for most applications, but in the military, there are multiple radios of every sort, not only for voice but also for video and data.

It is often difficult — if not impossible — for the Army to talk to the Air Force or the Marines to the Army and so on. Most radios do not interoperate with other radios. This greatly curtails

communications unless multiple radios are available. This problem also exists in law enforcement, search and rescue, and other public services. The fireman cannot talk to the police who cannot talk to the Coast Guard and so on. It is a huge problem and only getting worse. A potential solution is a special adaptive or smart SDR. It is being called cognitive radio.

Cognitive radio is an extension of SDR that combines the flexibility of the SDR with some intelligent features that allow the radio to learn and adapt. This smart radio will observe what the user does and remember selections and operations. It will also monitor the environment, meaning the frequency spectrum so it is aware of what is going on across a wide swath of spectrum. It will automatically adjust itself to the prevailing conditions to ensure that the communications take place. It will change frequencies to avoid interference. It

will change modulation modes to improve communications reliability or adapt to new conditions. It will boost transmitter power to overcome noise at the receiving end. And so on.

This smart radio will help conserve spectrum space by allowing the radio to operate in an area not currently used by anyone else. In other words, massive frequency reuse on the fly. And a neat aspect of a cognitive SDR is that it can download new software and reconfigure itself as the situation requires. The Federal Communications Commission (FCC) does not permit that now, but it is changing its rules to test and potentially allow future cognitive radio concepts to be implemented.

Cognitive radio is not here yet but it is being researched and tested. It will no doubt appear first in the military's JTRS radios. We may eventually see it in another 10 years, but it will change radio forever. **NV**

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## A MESMERIZING "CLOCK WATCHER'S" LED CLOCK FROM AUSTRALIA

Jaycar Electronics, based in Australia, has developed a new clock kit that blows other clock kits out of the water. It was developed in conjunction with *Silicon Chip Magazine*, an Australian-based electronics magazine.

The project is based around an AVR microcontroller, to take care of processing the display. It has a regular looking array of LEDs (arranged similarly to a bank of seven-segment LEDs) that displays the time in 12 or 24 hour mode. The real excitement however, is in the 60 LEDs around the circumference that make up the seconds counter.

When the clock is running, the "seconds" are kept by a chase LED running counter-clockwise from the 12 o'clock position back to the relevant "seconds" position. The first "second" sweep from the 12 o'clock position to its permanent location takes exactly one second. This position then remains illuminated. The next second (while only travelling 58/60 as far), still takes one second. This procession continues until the entire 60 seconds are lit up. Even though the sweep at 45 seconds is only 25% as far as the first, it still takes one second to make the journey. When the entire face has filled, one minute has elapsed, the digital clock increments by one, and the whole process starts all over again.

The kit is supplied complete with a 7-3/8" diameter circuit board which is a double-sided, plated through PCB with overlay, all PCB components, a pre-programmed AVR



microcontroller, and clear instructions. It only requires a 9VAC wall adaptor.

Price for this kit is \$82.95 + P/P. Use part number KC-5404 when ordering.

For more information, contact:

### JAYCAR ELECTRONICS

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## SPRACKET® SPEAKER MOUNTING SYSTEM

The Spracket® is a conductive speaker mounting system which allows you to connect speaker wire directly to the bracket. Its innovative design simplifies the process of mounting a speaker box to a wall. In addition, when using the Spracket, you create the flexibility to transport the speaker to multiple locations. Spracket is unlike other speaker mounting systems. It offers a unique marriage of a speaker bracket and connecting system, which eliminates the problems inherent to all previous speaker bracket designs (Hang And Hear®).

Current speaker bracket designs often require two pairs of hands to mount a speaker to a wall. The wire must reach the speaker being held by person A while person B inserts the positive and negative wires into the speaker connectors. The excess wire then has to be fed back into the wall, out of the bracket's way. Often, the wire will hang up on the bracket or disconnect and fall back into the wall. And so the process starts over. Even if none of these complications arise, two people are still needed to complete the installation. After hanging a speaker with standard wall brackets, one can't be sure if the two pieces are seated properly and that the speaker won't fall down with the slightest vibration.

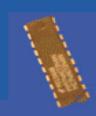
Spracket has a sturdy nylon 66 w/15 percent glass fiber construction and incorporates gold-plated copper contacts for maximum conductivity. Spracket is designed to hold up to a 50-pound speaker to a wall.

The Spracket incorporates positive and negative gold-plated copper contacts, isolated in a composite "J" mount design. The speaker wire from the wall is attached to the back of the Spracket utilizing bolts through the two contacts. The Spracket is then attached to the wall in the upright position, using all four mounting holes. Two wires are attached to the second Spracket, then connected to the speaker terminals. The Spracket is then

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mounted upside down to the back of a speaker. Only one pair of hands is necessary for installation. When the speaker is hung on the wall, sound provides confirmation that the Spracket is safely seated and operational.

The Spracket can be wired and mounted to any wall inside or outside your home, office, mobile home, or boat, or to areas of the home or business that seldom need a speaker system installed, such as a guestroom, conference room, or a dining area. Installations on unusually high wall mountings are also simplified. Speakers can then be easily moved from these locations for cleaning purposes or to relocate to another indoor or outdoor Spracketed location. The Spracket often has wide-range appeal to audiophiles, home-owners, pre-fab contractors, businesses, and boat or mobile home owners.

For more information, contact:

### CEWL CONNECTIONS

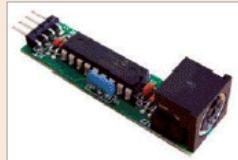
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Circle #66 on the Reader Service Card.

### ezKEY

The ezKEY is a simple-to-use adapter that allows you to use any PS/2 compatible computer keyboard with a microcontroller, Stamp module, or other embedded device. Access to the connected keyboard is through a standard 2-wire, 9600 baud, TTL level serial interface. This allows the end-use application to talk to the keyboard without any knowledge of the PS/2 protocol, keyboard scan codes, or PS/2 command set. The ezKEY takes all the scan codes and turns them into single byte ASCII codes relieving processor strain from the end-use controller.

The ezKEY commands allow the application to initialize the connected keyboard and review keystrokes. The ezKEY also comes with a 40-character buffer to help store keystrokes between readings. The ezKEY automatically controls the status of the num lock, caps lock, and scroll lock LEDs and



monitors the states of the shift keys. This allows the ezKEY to report the correct ASCII code without the end-use application having to monitor status and make any necessary changes, such as whether to use lower-case or upper-case.

The ezKEY comes with a SIP module that measures only 2.1 by 0.551 inches. A four-pin header is provided to supply power to the adapter and access the serial data lines. The ezKEY is also provided with a standard PS/2 receptacle to plug your keyboard into.

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With the addition of the ezKEY, Multilabs has created a complete user interface solution for microcontroller systems. The ezVID series of video modules, ezMOUSE PS/2 mouse adapter, and the ezKEY can all be used together to create a complete user input/output solution.

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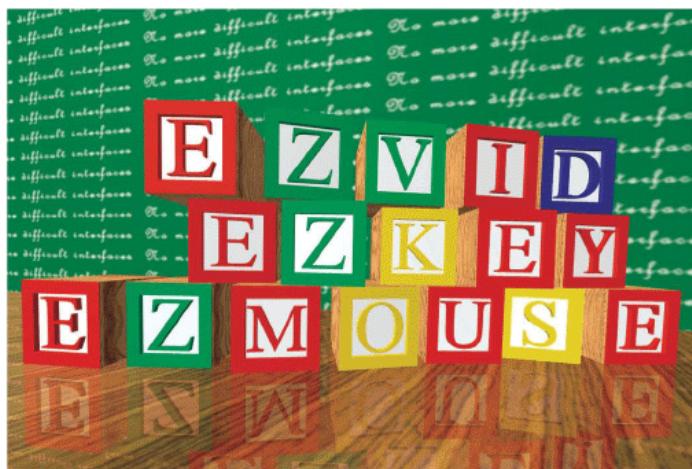
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## MICROCONTROLLER MODULE

The new MicroBolt embedded microcontroller module from Micromint is aimed at industrial control applications. The module uses a Philips LPC2106 microcontroller and can be programmed in C or assembly language.

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digital I/O, a real-time clock calendar, two UARTs, six PWM channels, an SPI bus, and an I2C bus. The MicroBolt can be used as a hardware replacement for Parallax Inc.'s BASIC Stamp. Micromint, Inc., offers a development package consisting of a development board with power supply, a MicroBolt Module, and a demo version of ImageCrafts ICCARM C compiler. The MicroBolt costs \$99.00

For more information, contact:

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## SERIAL TO ETHERNET CONVERSION SYSTEM

NetMedia, Inc., now offers a serial to Ethernet Conversion System.

The SitePlayer Telnet™ System (SPTS - \$ 79.95) allows the user to communicate directly with a device, through Telnet. With SitePlayer Telnet, users will be able to make an RS232 serial device accessible from anywhere there is an Internet connection. Once connected, the Telnet system acts as a transparent cable between the user and their device, allowing bi-directional communication between the user and the device. It can be configured using a standard web browser and can be password protected.

The durable aluminum case is compact, measuring 2.2" x 2.7" x .95". Other features include: a fully configurable RS232 serial port; a baud rate selection from 50 to 115,200; parity selection odd, even, or none; flow control selection; data bit selection; and six available control signals.

Flash ROM software updates can be uploaded to the device. It is configurable for up to four IP address, has a single LED which indicates online status, and includes an external power adaptor. The system is completely assembled and includes the SitePlayer Telnet module (also sold separately - SPT1 - \$ 29.95). Two SitePlayer Telnet devices can be used to create an Internet bridge between two serial devices.

For more information, contact:

## NET MEDIA, INC.

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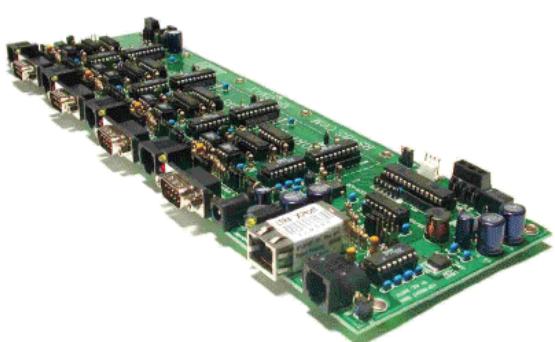
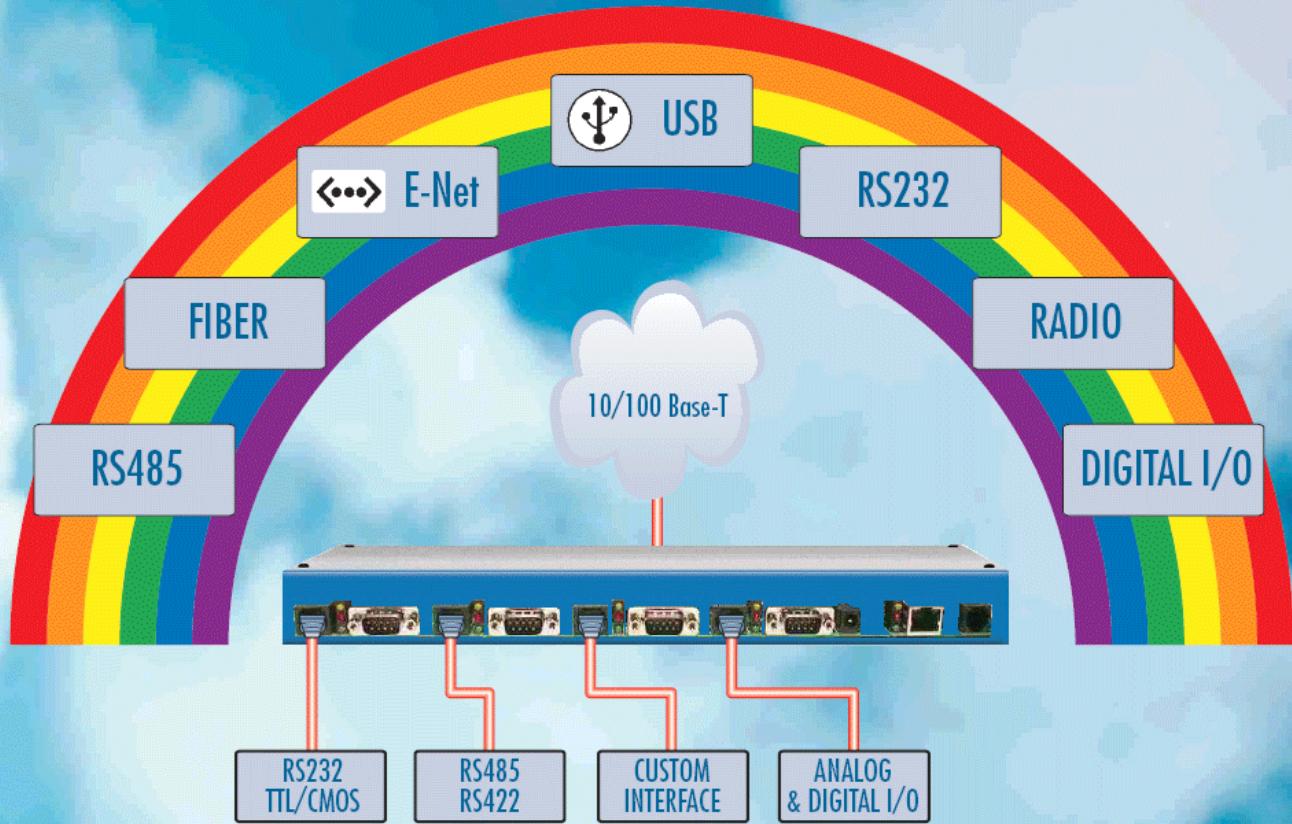
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# What the L is it?

## Check Inductors Quickly With a PIC-Based Meter That Also Measures Frequency

### This Month's Projects

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### The Fuzzball Rating System

To find out the level of difficulty for each of these projects, turn to Fuzzball for the answers.

The scale is from 1-4, with four Fuzzballs being the more difficult or advanced projects. Just look for the Fuzzballs in the opening header.

You'll also find information included in each article on any special tools or skills you'll need to complete the project.

Let the soldering begin!

**A**fter doing the same thing many times, I'll sometimes stop and ask myself why I'm doing it that way. A while back, I designed some DC-DC converters so I wound and measured a lot of inductors. Each time, I soldered a 5,000 pF 1% mica capacitor across the inductor. Then I hooked up a signal generator and checked the combination's resonant frequency on an oscilloscope. Five seconds on my HP-11C calculator gave me the inductance.

Was there a simpler solution? My existing procedure couldn't be easily automated, but there was an alternative. I could plug an unknown inductor into an LC oscillator and measure the resulting frequency. I'd have to design an oscillator that would work with a wide range of inductors and devise something to measure the frequency and display the corresponding inductance.

The latter was no problem. Small PIC microcontrollers can be programmed to

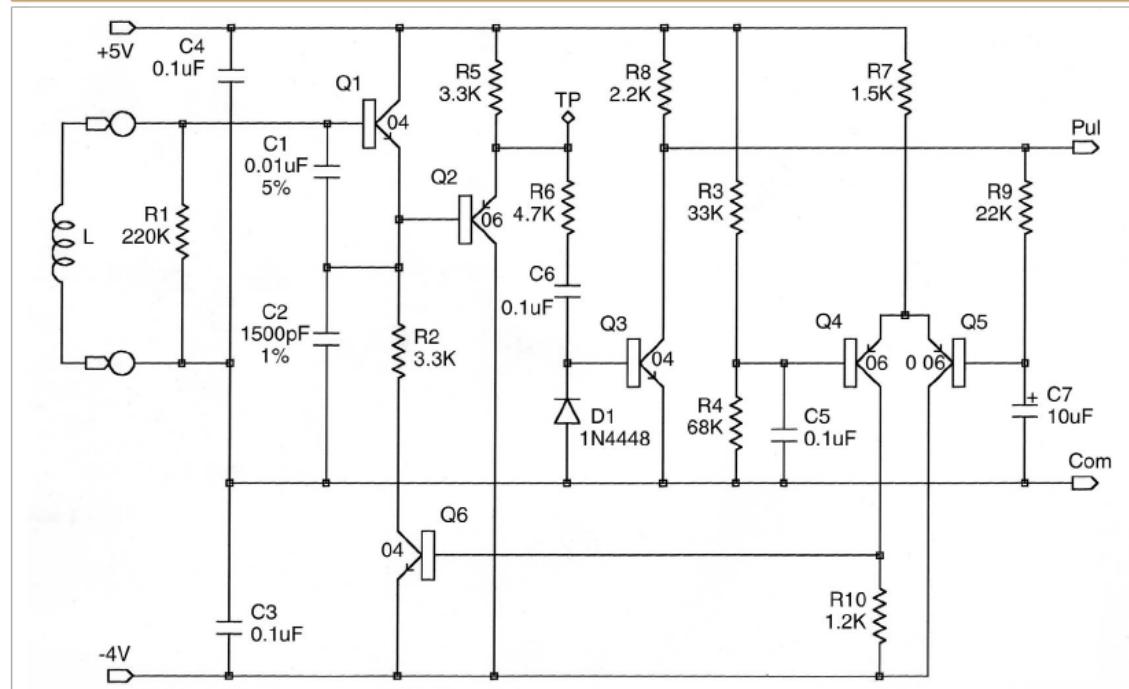
measure and display frequencies to tens of MHz. Knowing the tuning capacitance, a PIC could easily calculate and display the inductance. Put a wide-range oscillator in front and I'd have a handy device that would measure both inductance and frequency.

### Which Oscillator?

As this circuit must work with almost any inductor, I chose a Colpitts oscillator. This resonates an untapped inductor with two capacitors in series and uses an emitter-follower as its amplifying device. The slight voltage step-up provided by the capacitors balances the below-unity gain of the emitter-follower.

In Figure 1, C1 and C2 are the tuning capacitors and Q1 is the emitter-follower. (All NPN transistors are type 2N3904, PNP transistors are 2N3906s. Close equivalents will suffice in both cases.) The rest of the circuit provides a sine and a pulse output and

**Figure 1.** This oscillator, with its output buffer and gain control circuit, runs well with almost any inductor.



## What the L is it?

maintains a constant oscillation level.

This configuration has a number of nice features. Not only are both the inductor and the critical tuning capacitor grounded on one side, but the larger capacitor swamps the effect of the transistor's highly variable base-emitter capacitance. The transistor's collector-base capacitance can be ignored.

The oscillation frequency is inversely proportional to the square root of the inductor value. Thus, a 10,000:1 range of inductance can be measured with only a 1:100 range in frequency. This meter measures inductors from 3.3 uH to 100 mH.

## The Critical Capacitor

The tuning capacitance has to be large enough to swamp the inductor's self-capacitance and any strays introduced by the user's hand holding it in place. The resulting, relatively low operating frequency reduces the effect of core losses and the skin effect. On the other hand, if the oscillation frequency is too low, the circuit Q could become too low for the oscillator to run at all. I chose 1,300 pF ( $C_2 = 1,500 \text{ pF}$ ) as a good compromise. This gives oscillation frequencies between 12 kHz and 1.4 MHz.

The accuracy of the inductance measurement depends directly on the precision of capacitor  $C_2$ . Since  $C_1$  is much larger than  $C_2$ , its accuracy has less effect. I had several 1% capacitors in my junk box and assumed that such parts were readily available. While capacitor manufacturers offer them, my usual distributors don't stock capacitors with better than 2% accuracy. You may have to settle for one of those. Only mica or plastic foil capacitors should be used for  $C_1$  and  $C_2$ . Ceramic capacitors tend not to have close tolerances and often vary considerably with temperature.

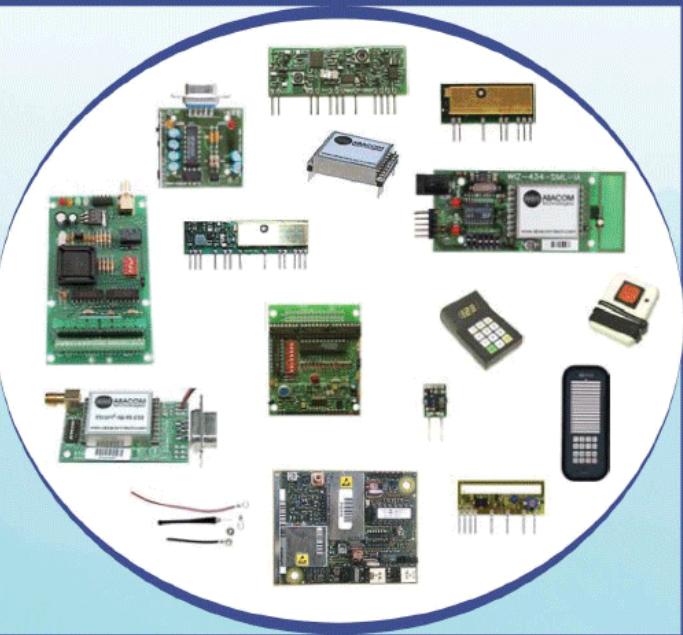
## Setting the Level

I wanted a constant output voltage for any inductor, so I added automatic gain control. This adjusts the DC current through  $Q_1$  over a 10-1,000 uA range to generate a two-volt peak-to-peak sinusoidal output at the test point TP. This sine output, buffered by  $Q_2$ , makes this oscillator a useful signal source for other purposes.  $Q_3$  converts the sine wave into pulses to drive the frequency meter.

Over the entire inductance range, the working impedance of the oscillator ranges from about 80 ohms to 8,000 ohms. To achieve a two-volt peak-to-peak output with a low-Q, 10 uH inductor requires a drive around 1.2 mA. At the other end of the scale, a high-Q, 100 mH inductor should generate a two-volt signal with only 1.2 uA drive. (The 20 uA or so of  $Q_2$ 's base current confuses things a little.)

The oscillator drive current comes from transistor  $Q_6$  whose base is driven by a voltage source. The collector current of  $Q_6$  is an exponential function of its base-emitter voltage which, in its turn, is proportional to the difference

## RF MODULES



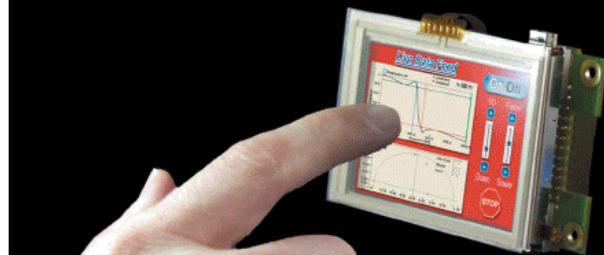
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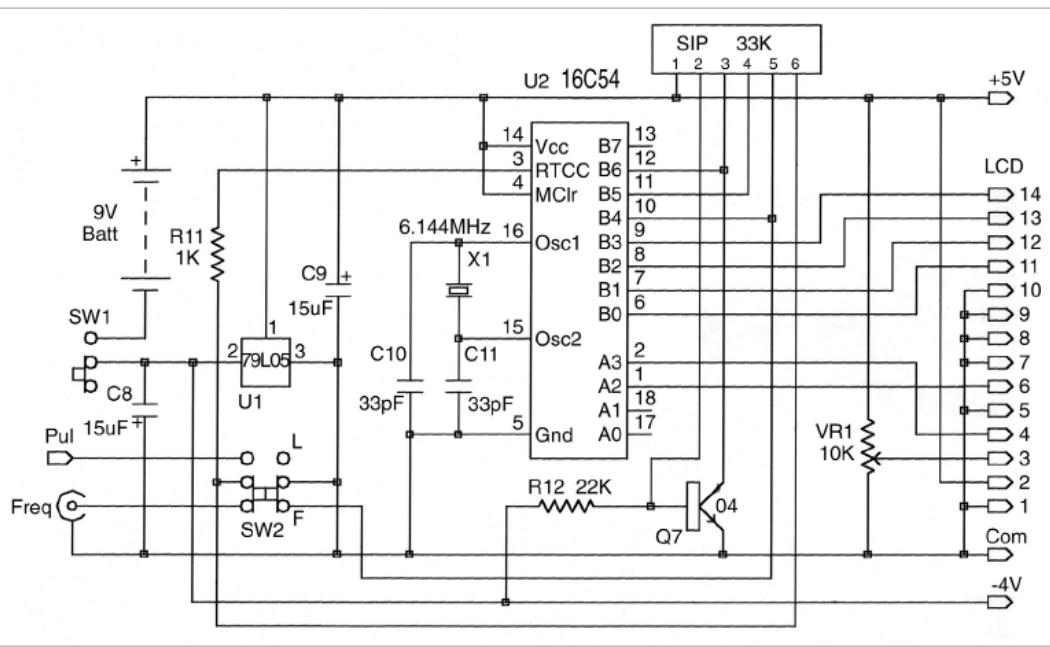
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**Figure 2.** The display driver uses a PIC microcontroller programmed to measure and display both frequency and inductance. It drives a cheap LCD with the result.

between the desired output amplitude and a fixed reference. R2 prevents Q1 from drawing a huge current when no inductor is being tested. R1 not only defines the open-circuit base voltage of Q1, it sets a limit to the circuit Q when measuring large inductors. Q4 and Q5 compare the DC level of the output pulses with a reference voltage derived from R3 and R4.

The feedback loop has two rather desirable side-effects. One is that whatever the current in Q1, the output amplitude is a fixed function of the control voltage. This makes stabilizing the control loop much easier. In a linear circuit, the loop gain would change from one end of the range to the other.

The other side-effect is the loop's independence of temperature. A transistor's exponential characteristic is very sensitive to the operating temperature; normally, you need extra transistors to compensate for this. When everything's inside an amplitude feedback loop, the loop compensates for temperature, as well. (The ambient temperature changes the threshold of Q3, producing a slight amplitude variation with temperature.) Within reasonable limits, the battery voltage has no effect.

The lowest oscillator frequency is about 12 kHz. With a high-Q inductor, the response to drive changes could be quite slow and, for a stable loop, the feedback has to be even slower. I was tempted to design a clever second-order loop but settled for a slow first-order one. That's why C7 is comparatively large. As it takes a significant fraction of a second to measure an inductor, we don't need a super-fast control loop.

## Does it Work?

Actually, rather well. Having designed for a maximum

frequency of about 1.4 MHz, I was a bit surprised to find the oscillator ran with much smaller inductors than the 10 uH I'd intended. The limit is about 0.47 uH, but by then the oscillator is running at 6 MHz and the TTL pulse converter is no longer doing its job. The PIC firmware allows inductance measurement down to 3.3 uH. At the LF end, the sine output at 12 kHz is a little warped but things work well enough. The display format cuts measurement off at 99.9 mH.

## You Can Count on a PIC

I like to stick with old and trusted parts, so I used a 16C54 for this job. Any of the 18-pin 16C5x series chips will work (see the Picking a PIC sidebar). Given a large enough internal prescaler ratio, the PIC's timer input can count frequencies approaching 50 MHz without missing a beat. The timer register and two overflow registers accumulate the input pulses for a firmware selected period. The number of pulses counted indicates the frequency. This frequency can be displayed as-is or converted into an inductance. The result is sent to a 16-character liquid crystal display (LCD).

For the PIC's clock, I used the popular 6.144 MHz crystal frequency. This gives a nominal maximum timer input of 1.45 MHz, but using the PIC's internal prescaler with its minimum division ratio (2) doubles this to 2.90 MHz. Without prescaling, the timer pin requires a roughly equal on/off pulse input. With the prescaler in-circuit, any pulse over 10 nS gets counted. As the oscillator generates short pulses, prescaling is a good idea.

## A Free Frequency Meter

The inductance meter in Figure 2 measures the oscillator frequency and displays the corresponding inductance about three times a second. In frequency meter mode, selected by a slide switch, a TTL level input frequency is counted for two seconds and displayed with 1 Hz resolution from 0.000 to 999.999 kHz. In both modes, a carefully counted number of instructions is executed between the start and finish of input sampling.

Don't take more than the first four frequency digits too seriously. The crystal frequency depends on the values of C10 and C11, among other things, and can be

in error by one part in 5,000 or so. If you don't need an inductance meter, you can use the PIC plus an LCD as a compact 1 MHz frequency meter. Of course, if you only want an inductance meter, you can leave out the BNC connector and the L/F switch.

## Self-ranging

When measuring inductance, the input frequency lies somewhere in a 100:1 range. Using a short counting period would result in loss of resolution at the low end of the range, while a longer period would lead to a total count greater than two bytes. I compromised by dividing the frequency range into high and low decades. The easiest way to achieve this was to use two counting periods, 40 mS and 400 mS. If the 40 mS count is greater than 2,765, it's processed as-is. Otherwise, a 400 mS count is done and a factor of 100 is incorporated into the inductance display.

## Counting Loops

The timing loop has to perform two tasks: to keep track of how many instructions have been executed and to look for overflows from the PIC's timer register, RTCC. With a times-two prescaler, the RTCC register overflows

every 512 input pulses. We must read it more often than that and increment a carry register any time RTCC shows a decrease from its last state, that is, if an overflow has taken place. The sampling and updating loop executes once per 256 instructions and repeats every 166.7 uS.

A further counting loop executes 60 of these 256 instruction sampling cycles and thus repeats every 10 mS. Its loop counter is preset to 4, 40, or 200 to give 40 mS, 400 mS, or 2 S periods.

When nesting loops this way, put several NOPs at the start of the inner loop. After N times around the inner loop, it's time to decrement the outer loop, to reload N, and start the inner loop cycling again. This takes five or so extra instructions. You play catch-up by jumping into the inner loop below the NOPs, making the first cycle shorter than a regular one.

## Computing the Answer

Commercial inductors generally have 10% tolerances. Except when comparing matched inductors, there's little point in making very accurate measurements. A three-digit indication in mH or uH units is perfectly adequate. The nominal range is from 10.0 uH to 99.9 mH. The display indicates when the inductor is too high or too low to measure.

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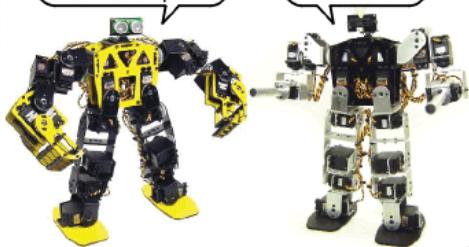


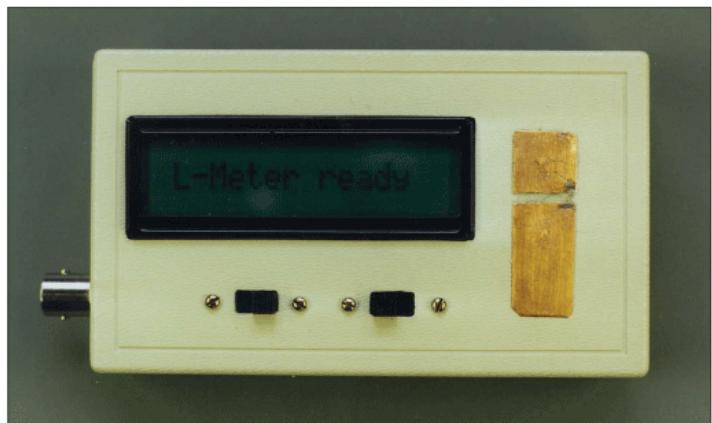
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**Figure 3.** I decided not to spoil the meter's elegant simplicity with clumsy labels. The display tells you that the meter is on and what mode it is in.

To convert a frequency to an inductance, a three-byte calibration constant is divided by the frequency and the result is squared. This is then converted to decimal form for the display. This process has to work on numbers from 3,000 to 30,000 without overflowing or losing resolution.

The constant is multiplied by 256 before being divided by the 16-bit count. The 16-bit result is squared, giving a 32-bit number whose lower two bytes are ignored. This corresponds to the inductance in units of 0.1 uH or 0.01 mH, depending on the range. This is converted into a four-digit BCD string whose first three non-zero digits drive the display. Luckily, 32 by 16 bit division, 16 by 16 multiplication, and BCD conversion are library functions I've used many times.

## Powering It

This oscillator (and some LCDs) requires a negative power rail. A negative three-terminal regulator derives

## Picking a PIC

The Microchip PIC16C5x series of low-level microcontrollers come in 18 and 28 pin packages and offer a range of both program (EPROM) memory and register (RAM) memory. They are available in erasable versions having a ceramic package with a UV transparent window and in one-time-programmable (OTP) plastic packages that can only be programmed once. For amateurs, the ability of the windowed parts to be erased and reprogrammed far outweighs their higher price-tag. The UV erasable part is 16C54C/JW.

Recent 16C5x revisions are not only cheaper, they run twice as fast as their predecessors, up to 40 MHz rather than the original 20 MHz. This project needs just less than the minimum available code and register space, so even the humblest of 16C54 chips will do the job. It won't hurt to use a 16C56 or 16C58 and the revision level doesn't matter. This is a great way to reuse any old, slow PICs you have lying around.

The PIC must be programmed with the code LMETER.OBJ (INHX8M format) which is available from Nuts & Volts website's FTP library ([www.nutsvolts.com](http://www.nutsvolts.com)).

both positive and negative supplies from a nine-volt battery. The positive (+5 V) rail that drives the PIC is the battery's positive terminal. Its negative terminal supplies about -4 V to the oscillator. For convenience, I used a 79L05 regulator. This has the disadvantage of 3 mA stand-by current. You can save some battery power by substituting a low-power negative regulator for the 79L05. The battery consumption is about 7.5 mA, so you can expect a battery life in the 50 to 100 hour region.

One PIC port acts as a go/no-go battery voltage sensor. A "Battery Low" message is displayed when the battery voltage — about 7.5 V — is too low to maintain a regulated five-volt supply.

## Packing it In

One has the usual options. Shoe-horn everything into the minimum plastic case possible or use a bigger box that takes up more space on the bench-top. I went for the first option even though it required more design work. My meter is wedged into the 4.5" by 2.7" box shown in Figure 3.

The display cut-out allows the bezel to protrude, letting the display board lie against the inner surface of the box and be glued to it with some silicone rubber. This leaves more height for the other components.

I filed the inner edges of the pillars which hold the box together to mount the LCD a little closer to the edge of the box. One edge of the LCD board protrudes into the battery compartment but doesn't get in the way. This edge could be trimmed off if necessary. (You might be more comfortable using a larger box.)

The circuit board is mounted behind the display. My display had its connector pads in its top left corner. This dictated the layout of the front panel and the size of the circuit board. I had to bend some of my design rules to make things fit. Figure 4 shows the result.

The primary mechanical support for the board is the row of wire-wrap pins I soldered to it. They mate with a female connector soldered to the LCD. Soldering both ends of the pins is an alternative. Pins on the lower edge of the board add rigidity and, incidentally, couple the test pads and the battery to the board. Since only connector friction holds the board in place, I glued some foam draft-excluder tape to the bottom of the box to stop the board from working loose.

The contact pads for the inductor under test are a piece of very thin single-sided PC board glued to the front panel over the battery compartment. I cut away some of the insulating material with a dental drill to make invisible connections to the undersides of the pads. In the ideal world, the pads would be gold-plated and the battery would be shielded from the "live" pad to eliminate its stray capacitance.

Apart from the display, the only other front-panel features are the two slide switches. One turns the meter on and off, the other selects frequency or inductance mode. VR1, a

trimmer on the PC board, sets the contrast of the LCD.

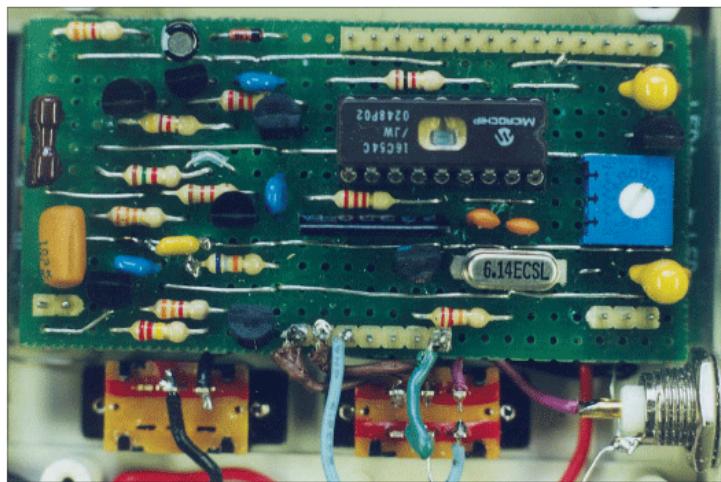
## Board Construction

I rarely use printed circuits for prototypes, preferring perforated prototyping board with continuous copper strips on one side. I cut a board 1.5" by 2.9" with the copper strips parallel to the short side of the board. The strips are cut as necessary. Bus-wires are added on the component side before the components are inserted. This makes for a neat layout and is far easier than etching a custom printed circuit. Figure 5, which can be viewed at the *Nuts & Volts* website ([www.nutsvolts.com](http://www.nutsvolts.com)), shows the component side of the board. Pairs of short parallel lines indicate where a copper strip on the underside must be cut through. The thick horizontal lines represent bus wires. Diamonds show where these are soldered to the copper strips.

Unfortunately, I couldn't quite squeeze in all the components. C5 is wired between other components, the leads of R5 must be bent inwards before soldering, and R7 has to bend around a jumper wire.

## Finding a Display

Two good sources of cheap displays are All



**Figure 4.** If the 1.5" by 2.9" circuit board is mounted directly on the display, the entire unit fits in a 2.7" by 4.5" project box.

Electronics ([www.allelectronics.com](http://www.allelectronics.com)) and Marlin P. Jones & Association ([www.mpja.com](http://www.mpja.com)). You need a one-line by 16-character display. The description may not specifically say "reflective," but that's the kind you want. If "transmissive" or "backlight" are mentioned, you're looking at the wrong type, it won't run from a battery.

No particular display is guaranteed to remain in stock.

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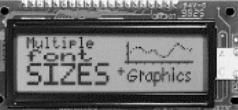
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I used the LCD-75 from All Electronics but by the time you read this, they may have some other 16-character displays in stock. As these are around \$5.00 each, you can probably afford to experiment.

Not all displays use the same pinout. The standard I've assumed is a 14-pin single row on a long edge of the board. One snag is that, in some displays, the connector pads run along the bottom edge of the board and in others, the top edge. Often you can't tell which is which without powering up the display. The one I bought had its connector above the display even though the lettering on the PC board implied that the display should be mounted the other way up.

Check which pad is number 1. It's the ground pad

## Parts List

U1	79L05	Negative voltage regulator
U2	PIC16C54C/JW	See sidebar
Q1, Q3, Q6, Q7	NPN transistor, 2N3904	
Q2, Q4, Q5	PNP transistor, 2N3906	
D1	Small signal diode, IN4448 or similar	
X1	6.144 MHz crystal. (e.g., Digi-Key type X414)	
All resistors 5%, 0.25W		
R1	220K	
R2	3.3K	
R3	33K	
R4	68K	
R5	3.3K	
R6	4.7K	
R7	1.5K	
R8	2.2K	
R9	22K	
R10	1.2K	
R11	1.0K	
R12	22K	
VRI	10K trimmer	
SIP	Six-pin 33K, common connection to pin 1	
C1	0.01 uF 5%, plastic foil	
C2	1500 pF 1%, mica or plastic foil	
C3, C4, C5, C6	0, 1 uF 20%, ceramic	
C7	10 uF 16V, electrolytic	
C8, C9	15 uF 20V, tantalum bead	
C10, C11	33 pF, ceramic	
SW1	On/Off slide switch	
SW2	Two-pole, two-way slide switch	
LCD	One line by 16 character reflective display	
Plastic project box		
Prototyping board (e.g., All Electronics #ECS-4)		
Male and female single line connectors		
BNC connector		

and is connected to the bezel of the display. If it's at the "wrong" end of the row, the meter board must be mounted upside-down to make the pins match. Reflective displays sometimes come with two extra pads (15 and 16) to drive the non-existent backlight. These can be ignored.

The other common connector standard is a double row of pads on the short edge. This makes for a convenient ribbon cable interface but such a display would be too long to fit the box.

In my experience, 16-character, single-line displays behave electrically as if they were eight-character, two-line displays. That is, they use two separate sections of display memory to store the first and second eight-character block. (This minimizes driver chips.) The PIC firmware takes this into account but offers the option of writing all 16 characters to a single block, letting you use one line of a two-line display as your output device. A jumper wire between the pins labelled DM and G in Figure 5 sets this mode of operation.

## Calibration

The relationship between the oscillator frequency and the displayed inductance is controlled by a calibration constant stored as three RET N instructions at code addresses 1, 2, and 3. The default value is 277,578 which corresponds to a tuning capacitance of 1,315 pF (C1, C2 and 11 pF of stray capacitance). If the strays are significantly higher, or if you measure large air-cored inductors with a high self-capacitance, the oscillator frequency will be lower than it should be and the meter will read high. If, when measuring accurately-known inductors, you get readings more than a percent or two in error, you might consider changing the calibration constant. If your meter gives consistently low inductance readings, this can be corrected by adding a 30 pF trimmer across the 1,500 pF capacitor.

This meter measures inductance under small-signal conditions. It has no mechanism for measuring how core saturation affects the inductance at high operating currents. Saturation is an important factor in DC-DC converter design.

## Pleased as L

After years of fumbling with capacitors and signal generators, it's extremely gratifying to be able to touch any old inductor to the contact pads and have the meter tell me its value. I hope you'll find it as useful as I do. **NV**

## About the Author

Tom Napier formerly worked for space and high-energy physics research organizations in Europe. Since 1982, he has developed innovative electronic equipment for companies in the US. He is now an electronics consultant based in SE Pennsylvania.

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- ♦ Regulated output 24 VDC at 1.67 A

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# The MIDI-nator

## Control Instruments on the Road with this Interface

I have been a fan of MIDI (Musical Instrument Digital Interface) since the 1980s. The idea of controlling musical instruments from a computer has always seemed cool to me. Over the years, I have owned a number of MIDI cards and interfaces for my computers. I finally got around to buying a notebook computer. One of the characteristics of the new portable was the lack of a classic parallel port or card slot. The general trend on new computers is the replacement of the classic serial and parallel ports with Universal Serial Bus (USB) ports. With the elimination of the classical ports and card slots, I lost my MIDI interface capability. Thus was born the USB to MIDI interface project — the MIDI-nator. With this project, I will give the portable computer the ability to control musical instruments.

### A Brief Introduction to USB

The USB 2.0 specification (Reference 1) supports three data transfer rates: high at 480 million bits per second (Mbps), full at 12 Mbps, and low at 1.5 Mbps. USB allows peripherals to be plugged and unplugged without down-powering the computer. This process, called “enumeration,” involves communicating with the peripheral to discover the identity of the device driver that should be loaded. A unique address is assigned to each peripheral during enumeration to be used for run-time transfers. During run-time, the host PC initiates transactions to specific peripherals, and each peripheral accepts its

transactions and responds accordingly.

From the peripheral point of view, all USB peripherals are slaves that obey a defined protocol. They must react to request transactions sent from the host PC. The peripheral responds to control transactions that, for example, request detailed information about the device and its configuration. The peripheral sends and receives data to/from the host using a standard USB data format.

USB 2.0 supports four types of data transfers: Control, Bulk, Interrupt, and Isochronous. Control transfers are bursty, non-periodic, host software-initiated request/response communications, typically used for command/status operations. Bulk transfers are non-periodic, large-packet bursty communications, typically used for data that can use any available bandwidth and can also be delayed until bandwidth is available. Bulk transfers perform error detection via CRC.

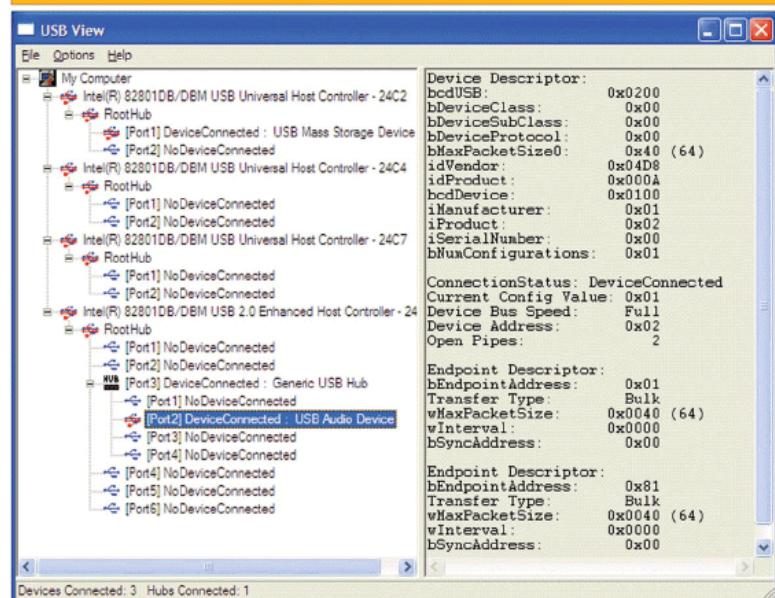
I will use control transfers during the enumeration process and bulk transfers for the MIDI data. It is important to note that bulk transfers include error checking and retry capability but no guaranteed delivery latency. Thus, it is possible for MIDI data to be slightly delayed if your other USB devices are extremely busy.

Microsoft has a tool available for examining the USB ports. USBView is a free utility from Microsoft (Source 1) that displays the USB connection tree and shows details of the USB devices that are connected to it, as shown in Figure 1. This is very useful for debugging USB enumeration errors. USBView runs under Windows 98/ME/2000/XP. USB ports transfer data through ENDPOINTS which are analogous to buffers.

### The Microprocessor

The PIC18F2455 is one of the new USB enabled Flash memory microprocessors from Microchip. The 24K bytes of Flash program memory allow the user to store about 12 thousand 16-bit instructions which can be erased and reprogrammed electronically. The Flash program memory supports 100,000 write/erase cycles and has a greater than 40 year retention period. The microprocessor has 2048 bytes of RAM data memory. The microprocessor has many of the features users have come to expect from Microchip: Universal Asynchronous Receiver/Transmitter (UART) module, four timers, 10 10-bit A/D channels, and a master synchronous serial port (MSSP). The MSSP is useful for communicating with peripheral devices such as serial

**Figure 1.** USBVIEW of MIDI-nator.



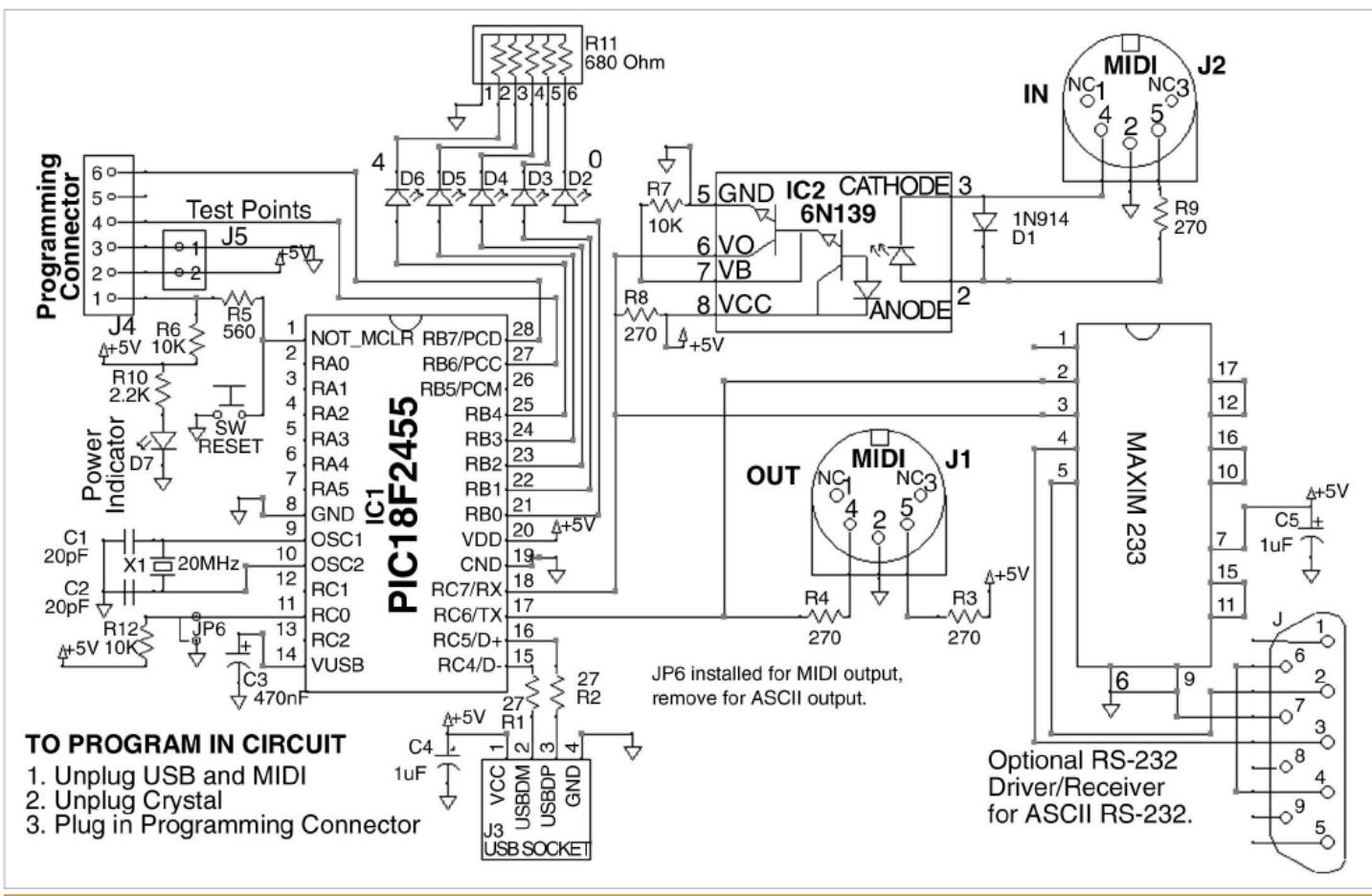


Figure 2. USB to MIDI Interface Schematic.

EEPROMS and supports SPI and I<sup>2</sup>C protocols. The PIC18F2455 has 75 base instructions and offers seven different operating modes for managing power consumption.

The USB engine is V2.0 compliant and operates at low (1.5 Mb/sec) and full (12Mb/sec) speeds. The USB engine supports all types of data transfers and up to 32 endpoints. It has one kilobyte of RAM starting at 400h that is shared between the CPU and the USB engine. This shared memory can be configured for optimum use by the user. The first few locations are defined in umidi.h and are used for endpoint (buffer) descriptors: BDnSTAT, BDnCNT, and BDnADR. The locations are defined by how many of the endpoints use dual (ping-pong) buffering. BDnSTAT is the status register for the nth endpoint. Bit 7 determines who owns the buffer (CPU or USB engine) and who can write to it. BDnCNT is the number of bytes in the buffer. BDnADR is the integer where the buffer starts in the 400h-7FFh range. The PIC18F2455 supports a dual buffering scheme in which case each endpoint has two buffers defined. Up to a total of 64 buffers can be defined.

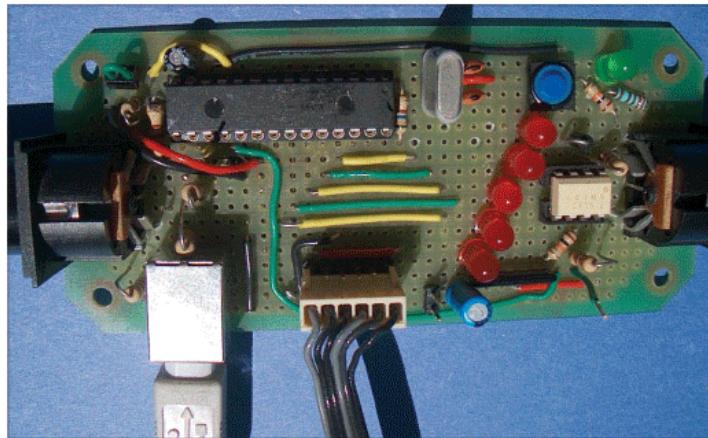
## Building the Hardware

The circuit for the USB to MIDI interface is fairly simple and is shown in Figure 2. The connections are few

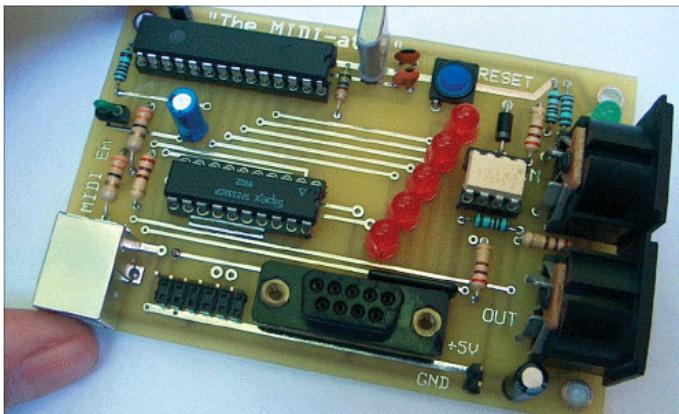
enough that it can be built on a 2" by 4.5" prototype board having hole spacings at 0.1". Figure 3 shows the layout of the components on the board, and can be viewed at the *Nuts & Volts* website ([www.nutsvolts.com](http://www.nutsvolts.com)). Component side jumpers are shown in red. The heart of the system is the programmed PIC18F2455 that handles the USB proto-

## References

- Reference 1 — Universal Serial Bus Revision 2.0 Specification at [www.usb.org/developers/docs/](http://www.usb.org/developers/docs/)
- Reference 2 — MIDI Manufacturer's Association at [www.midi.org](http://www.midi.org)
- Reference 3 — USB Device Class Definition for MIDI Devices at [www.usb.org/developers/devclass\\_docs/midi10.pdf](http://www.usb.org/developers/devclass_docs/midi10.pdf)
- Reference 4 — Programming the Microsoft Windows Driver Model by Walter Oney
- Reference 5 — Microsoft MSDN Library at [http://msdn.microsoft.com/library/default.asp?url=/library/enus/stream/hh/stream-aud-design\\_2951b252-9b80-4b59-82de-bce22fd1203e.xml.asp](http://msdn.microsoft.com/library/default.asp?url=/library/enus/stream/hh/stream-aud-design_2951b252-9b80-4b59-82de-bce22fd1203e.xml.asp)
- Reference 6 — PIC18F2XX0/2XX5/4XX0/4XX5 Flash Microcontroller Programming Specification from [www.microchip.com](http://www.microchip.com)



**Figure 4.** Completed MIDI-nator Prototype Board.



**Figure 5.** MIDI-nator using Printed Circuit Board (with optional RS-232 debug output).

col and MIDI serial input and output. Preprogrammed PIC18F2455 chips can be obtained from Source 2. The MIDI input is optically isolated from the microprocessor by a 6N139 high speed, high gain Darlington optoisolator.

There are five LEDs that are used to announce the state of the microprocessor and a power LED. A 20 MHz

crystal oscillator provides the clock for the system and a manual pushbutton is used to reset the system. There is a programming connector used to bring programming signals from the programmer to allow in-circuit programming of the PIC18F2455. Two MIDI connectors and a USB connector complete the hardware. Power is provided through the USB connector. The completed circuit board is shown in Figure 4. For the initial debugging, I added an optional Maxim 233 RS-232 driver/receiver. This allowed me to send debugging data to be printed on the PC at 115,200 baud. Table 1 gives the parts list for building the USB MIDI interface board.

If you do not want to tackle building the device from scratch on a prototype board, a printed circuit board is available at Source 2. The completed device on the printed circuit board is shown in Figure 5. The printed circuit board includes connections for the optional RS-232 debug feature.

## MIDI Description

The MIDI enables people to use multimedia computers and electronic musical instruments to create, enjoy, and learn about music. There are actually three components to MIDI. The components are the communications Protocol (language), the Connector (hardware interface), and the distribution format called Standard MIDI Files.

I will discuss only the MIDI serial protocol in this article. The MIDI protocol is an entire music descrip-

Quantity	Part ID	Description	Source #	Part #	Cost Each
1	J3	USB B PCB connector	Source 5	230957	\$.99
1	PCB	Prototype circuit board Printed circuit board	Source 5 Source 2	105128	\$7.95
1	SW	Reset switch (momentary contact)	Source 5	162886	\$.45
1	R11	Resistor net, 6 pin, 680 ohm	Source 5	267872	\$.14
1	X1	20 MHz crystal	Source 5	14517	\$.79
2	C1, C2	20 pF disk capacitor	Source 5	15405	\$.07
1	C3	470 nF electrolytic capacitor	Source 5	158481	\$.05
2	C4, C5	1 uF electrolytic capacitor	Source 5	158490	\$.06
2	R1, R2	27 ohm resistor [1]	Source 5	30584	100 for \$1.00
4	R7, R3, R4, R8	270 ohm resistor	Source 5	30605	100 for \$1.00
1	R5	560 ohm resistor	Source 5	31376	100 for \$1.00
1	R6, R12	10K ohm resistor	Source 5	29911	100 for \$1.00
1	R10	2.2K ohm resistor	Source 5	30314	100 for \$1.00
1	D2-D7	LEDs	Source 5	206498	\$.15
1	J4, J5	Test points and programming connector	Source 5	103392	\$.18
1	IC1	PIC18F2455 microprocessor Preprogrammed available	Source 6 Source 2	—	\$7.76
1 optional	IC3	Maxim233 RS-232 driver/rec (debugging)	Source 5	106163	\$5.75
1 optional	J6	9 pin RS-232 female connector	Source 5	15780	\$.55
1	IC2	6N139 optical isolator	Source 5	113929	\$.65
2	J1, J2	5 pin DIN socket	Source 5	29399	\$.59
1	D1	IN914 diode	Source 5	179207	\$.05
		[1] All resistors 1/4 watt			

**Table 1.** USB MIDI Interface Parts List.

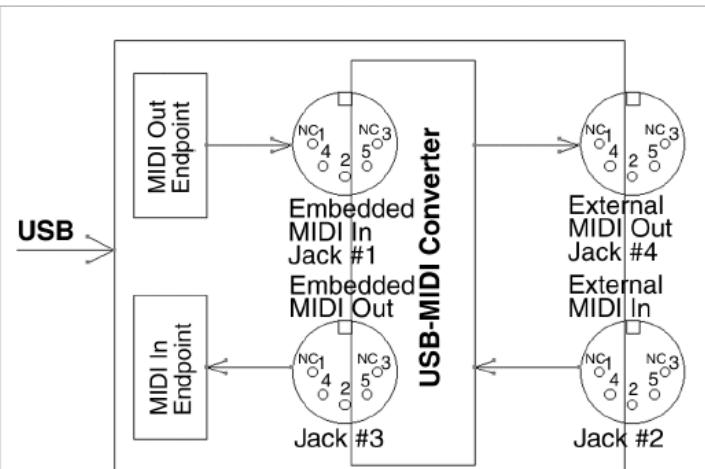


Figure 6. Simple USB-MIDI Interface.

tion language in binary form. Each word describing an action of musical performance is assigned a specific binary code. MIDI was designed for keyboards, so many of the actions are percussion-oriented. To sound a note in MIDI language, you send a “Note On” message, and then assign that note a “velocity,” which determines how loud it plays. Other MIDI messages include selecting which instrument to play, mixing and panning sounds, and controlling various aspects of electronic musical instruments. Table 2 gives a list of some of the MIDI status and data bytes. Notice that the status bytes and data bytes are differentiated by whether the high order bit is set or not. A complete list and description of the MIDI messages are given in Reference 2.

The characteristics of the MIDI serial protocol are that data is transmitted at a rate of 31,250 bits per second, there is one start bit and one stop bit, and the voltage levels are 0 and +5 volts. The PIC18F2455’s built-in UART can be used to send and receive MIDI data as long as these characteristics are met.

## USB Device Class Definition for MIDI Devices

The USB organization has defined the way MIDI data is transmitted over the USB connection in the USB Device Class for MIDI Devices (Reference 3). In the USB MIDI class, the MIDI data is sent in four-byte event packets as shown in Table 3. The USB-MIDI event packet provides a wrapper around a standard serial

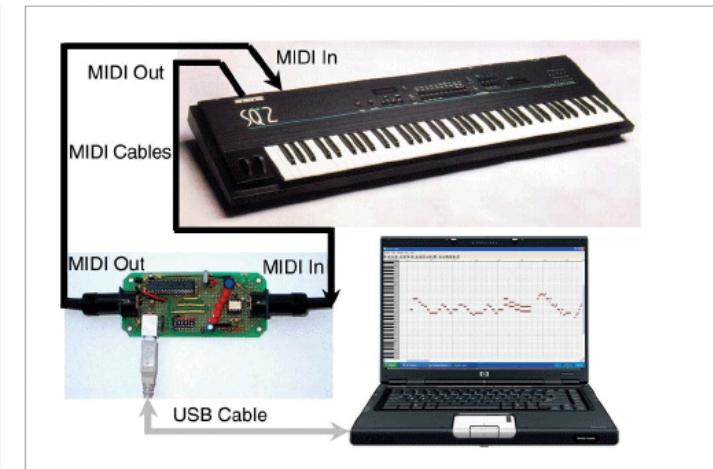


Figure 7. MIDI-nator Hookup Diagram.

MIDI command. New information is also added. The cable number is a value ranging from 0 to Fh.

The Code Index Number indicates the type of MIDI command that has been wrapped. In many cases, it is the same as the MIDI command. Perhaps an example would be useful. The standard MIDI command for a NOTEON of middle C on channel 0 with a velocity of 100 is 90 40 64 in hex. The corresponding USB-MIDI event packet for MIDI cable 1 is 19 90 40 64. It is the task of the USB-MIDI output device to receive the event packet from the personal computer (PC) via USB, decode it, and send the MIDI command

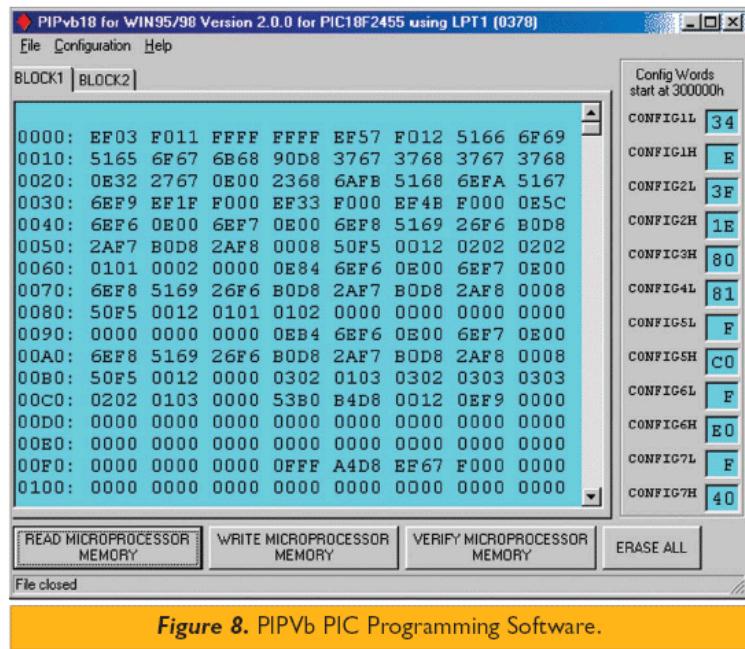
Status D7-----D0	Data Byte(s) D7-----D0	Description
1000nnnn	0kkkkkkk 0vvvvvv	Note Off event. This message is sent when a note is released (ended). (kkkkkkk) is the key (note) number. (vvvvvv) is the velocity. (nnnn) = 0-15 (MIDI Channel Number 1-16).
1001nnnn	0kkkkkkk 0vvvvvv	Note On event. This message is sent when a note is depressed (start). n, k, and v defined as above.
1011nnnn	0ccccccc 0vvvvvv	Control Change. This message is sent when a controller value changes. Controllers include devices such as pedals and levers. (ccccccc) is the controller number. (vvvvvv) is the new value (0-119).
1100nnnn	0ppppppp	Program Change. This message is sent when the patch number (instrument) changes. (ppppppp) is the new program number.
1110nnnn	0111111 0mmmmmmm	Pitch Wheel Change. This message is sent to indicate a change in the pitch wheel. The pitch wheel is measured by a 14 bit value. Center (no pitch change) is 2,000H. Sensitivity is a function of the transmitter. (1111111) are the least significant seven bits. (mmmmmmm) are the most significant seven bits.

There are many other MIDI commands. For a complete list, see Reference 2.

Table 2. MIDI Commands.

Byte 0	Byte 1	Byte 2	Byte 3
Cable #	Code Index #	MIDI status byte	MIDI data byte #1

Table 3. 32-bit USB-MIDI Event Packet.

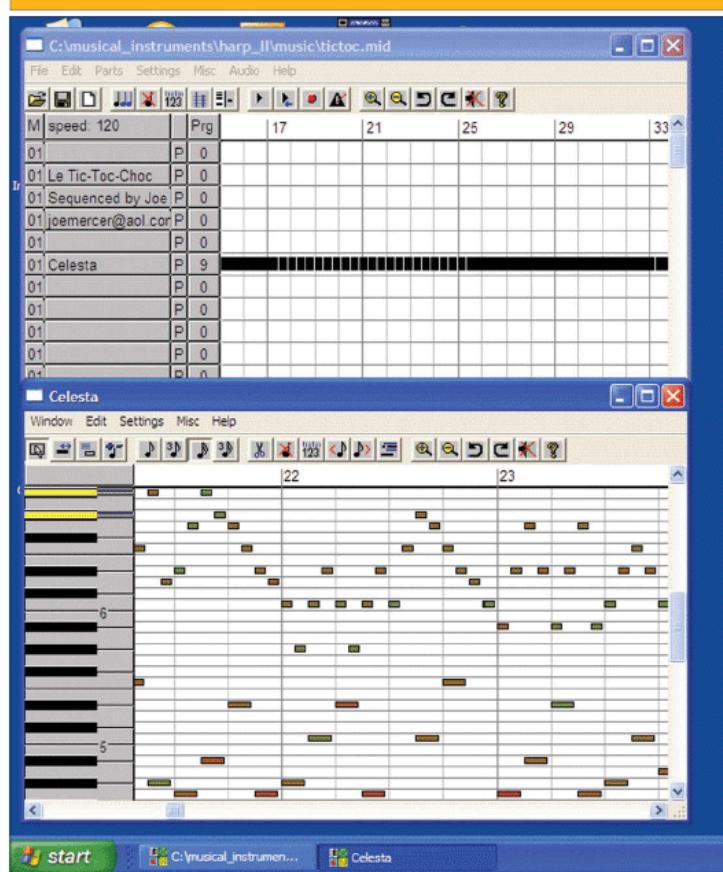


**Figure 8.** PIPVb PIC Programming Software.

out a serial line at 31,250 baud. For the USB-MIDI input device, the task is to receive the MIDI command over a serial line at 31,250 baud, prepare the MIDI event packet, and transmit it to the PC via USB.

The USB class definitions are a way to define the MIDI device as shown in Figure 6. The device is simple and will

**Figure 9.** Jazz Sequencer Playing MIDI file.



consist of two MIDI endpoints — an IN and an OUT. The OUT endpoint is connected to the embedded MIDI IN jack which is defined as Jack #1 in the USB descriptors in umidi.c. Jack #1 is connected to Jack #4 which is the external MIDI OUT jack. Jack #4 and its connection to Jack #1 is also defined in the USB descriptors. Likewise, the input MIDI flow is defined in a similar manner. The USB device class definition for MIDI devices allows for much more complicated MIDI devices with more jacks and elements like internal synthesizers. Figure 7 shows how the MIDI-nator can be hooked up to a music synthesizer MIDI keyboard and a notebook computer.

## MIDI Driver

In order to develop a piece of hardware for the Microsoft® Windows® XP operating system, it is necessary to take a step into the deep water with the Windows driver model. The Windows driver model allows developers to write device drivers that are source-code compatible across all Microsoft Windows operating systems (Reference 4).

By taking care to follow the standard USB device class definition for MIDI devices when writing the firmware for the device, I can use the standard Microsoft USB audio device drivers and avoid having to write my own custom USB MIDI driver. The following standard device drivers will be loaded: *USBAUDIO.SYS*, *KS.SYS*, *PORTCLS.SYS*, *KSPROXY.SYS*, *KSUSER.SYS*, *WDMAUD.SYS*, and *DRMK.SYS*. Using these standard drivers will save me weeks of work, hundreds of pages of reading, and many headaches. Alas, the USB MIDI drivers are only available on Microsoft Windows XP and later operating systems.

## Writing the USB/MIDI Software

The complexity of the USB and MIDI data processing indicated that the device firmware would be fairly long. I decided to write the program in C rather than assembly language and chose the BOOSTC compiler from SOURCEBOOST because of its low price and helpful support (Source 3). BOOSTC has an easy-to-use Windows user interface and the ability to single step through the program. The complete BOOSTC source code for this project is available at Source 4.

For the USB to MIDI interface to work with Windows, there must be a Windows driver that conforms to the specifications of the USB Device Class Definition for MIDI Devices. As I mentioned, Microsoft has written such a driver and it is included as part of the Windows XP operating system. The device's firmware must accept the driver's commands and supply the data in the format the driver needs.

Since the Windows XP USB MIDI driver conforms to the USB Device Class Definition for MIDI Devices, that document can be used for guidance in writing the

firmware for the PIC18F2455. Where to start when writing the firmware? The first thing that happens when a USB device is plugged in is enumeration. In enumeration, the host first puts the device into RESET mode and LED 0 will light. Then the host asks the device for a number of descriptors that help define the device to the host. Reference 3 defines the format and the content of the descriptors. The C program defines the descriptors in the DeviceDescriptor[] and Config-Descriptor[] arrays. Comments in the program provide an explanation of the contents of the descriptors. If the descriptors are processed successfully, then the device will be in configured mode and LED 2 will light. The MIDI-nator will show up in the system device manager as "USB AUDIO DEVICE."

There is a jumper on the board that is sensed by the software. The software is designed to output additional debug information if the jumper is removed. This will be discussed more in the testing part of this article.

When MIDI data is received from the host via the EP1OUT USB endpoint, it is decoded into serial MIDI data and loaded into a 128 byte circular output buffer for serial transmission. It is transmitted as quickly as possible using interrupts. When MIDI data is available from an external MIDI device via the RX pin on the PIC18F2455, an interrupt occurs and the MIDI data is loaded into a 128 byte

circular input buffer. The MIDI data is processed and assembled into four byte USB MIDI packets. The packets are then read by the host via the EP1IN USB endpoint.

BOOSTC or another C compiler is used to compile and link the C source into the umidi.hex file. The next step in the process is to download the hex file to the PIC18F2455 chip. For this, you will need PIC programmer hardware and PIC programmer software for the PC or you can order the preprogrammed chip from Source 2. There are plans for lots of PIC programmers on the Internet (Source 7) and free PIC programmer software (Source 8). Personally, I use the TAIT programmer hardware that uses the PC's parallel port and the PIPVb programming software shown in Figure 8. Just make sure the programming software is tested on the operating system you are using and works for the PIC18F2455 since the programming algorithm was changed by Microchip for this PIC (Reference 6).

## Testing the Hardware With the MIDI Software

Before you plug the device into your computer's USB port, you should check its operation by applying +5 volts and ground to J5. The first thing that should happen is that the LEDs will flash sequentially. This means that the

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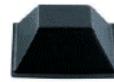
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device is powered and programmed. The device should draw less than 55 mA with the optional RS-232 feature. If it does not, stop and check the circuit. Do not plug the device into your USB port until you are sure your wiring is correct or you may damage your USB port. Some — but not all USB ports — have overload protection.

The next thing to do is to plug the device into your USB port and check that the device is properly enumerated. This can be done using the USBVIEW program. Figure 1 shows the output of the USBView program with the hardware and software of this article connected. USBVIEW shows that the device has one configuration and

has a maximum control packet size of 64 bytes. It operates at full speed and has two open pipes. The first pipe uses bulk data transfers and is for host-to-device data transfers (01) and has a maximum packet size of 64 bytes. The second pipe uses bulk data transfers and is for device-to-host data transfers (81) and has a maximum packet size of 64 bytes.

When I first plugged the device in with the program, it did not work. This meant I needed some way to debug the program. There is a jumper on the board that will switch the board from sending and receiving data at the MIDI baud rate (31,250) to a standard PC serial port baud rate (115,200). With the jumper in this position, additional debug information can be viewed by connecting the device to a PC with a serial port and using the HYPERTERM terminal program. Table 4 shows the commented output of a good enumeration and MIDI data transfer. Please note that in this mode the MIDI connections do not work, but can be simulated by sending MIDI commands from the HYPERTERM terminal program.

The USB Implementer's Forum provides a free program called USB Command Verifier (USBCV) at Source 9. USBCV evaluates high, full, and low-speed USB devices for conformance to the USB Device Framework. It runs a number of tests — such as causing the device to enumerate 150 times — which must be passed. I am happy to report that this device and software passed all the USB Command Verifier tests.

The final step in the testing of the device is to test the transfer of MIDI data into and out of the PC using the USB port. For this, a music sequencer program is needed. There are many sequencer programs on the market, such as CAKEWALK (Source 10) and

USB MIDI Debug Message	Comments
USB MIDI Interface V2.3	Announcement that program has started.
Full speed USB	Running at full USB speed.
USB Init	USB is initialized.
D>H	Device to host transfer.
GD	Get descriptor.
device	Descriptor type = device.
I2 01 12	First byte, last byte, and number of bytes transferred in hex.
H>D	Host to device.
SA	Set device address.
01	Device address is 1.
D>H . . .	Repeats device request.
D>H	Device to host.
GD	Get descriptor.
config	Descriptor type = config.
09 32 09	Sends first nine bytes of config descriptor.
D>H	Device to host.
GD	Get descriptor.
config	Descriptor type = config.
09 00 40	Send 64 bytes of config.
05 03 13	Sends last 19 bytes of config.
D>H	Device to host.
GD	Get descriptor.
string	Descriptor type = string.
04 04 04	Specifies string language.
D>H	Device to host.
GD	Get descriptor.
string	Descriptor type = string.
2a 00 2a	Sends product string.
D>H . . .	Repeats previous two strings.
D>H . . .	Repeats device and config descriptors.
H>D	Host to device.
SC	Set configuration.
01 C	Configuration is set to 1.
D>H . . .	Repeats two string requests.
EPIout	Some MIDI initialization.
0b b0 7a 00	Messages are received.
. . .	
09 90 3c 64	MIDI note on for middle C.
EPIout	
09 90 3c 00	MIDI note off for middle C. A note off is a note on with velocity of 0.

Table 4. Debug Output from Good Run.

many others available for free on the Internet, such as JAZZ (Source 11). The MIDI sequencer program can be used to play, record, and edit MIDI music files. To record a MIDI file, you need a music synthesizer MIDI keyboard for input.

Figure 9 shows the free JAZZ program playing a MIDI file. To record music in JAZZ, you just highlight the measures you want to record and hit the record button, then just play what you want to record on the music synthesizer MIDI keyboard. Don't worry if you make mistakes because you can always go back and edit the recorded MIDI file to correct any errors. One note of caution, however: Do not select the USB AUDIO DEVICE as both the input and the output in JAZZ when recording unless the output is muted. Doing so can set up an internal MIDI feedback loop which can cause havoc.

## Conclusion

An interesting project which allows new portable computers using the XP operating system to drive MIDI musical instruments has been constructed for about \$21.00. This project provides an introduction to the USB and MIDI protocols, to one of the new USB flash microprocessors from Microchip, and to the new low priced BOOSTC compiler from SOURCEBOOST. With this device, USB Notebook computers are now MIDI enabled. **NV**

## Sources

- Source 1 — USBVIEW available at [www.ftdichip.com/Resources/Utilities.htm](http://www.ftdichip.com/Resources/Utilities.htm)
- Source 2 — RLANG homepage at [www2.netdoor.com/~rlang](http://www2.netdoor.com/~rlang)
- Source 3 — BOOSTC Compiler at [www.picant.com/c2c/c.html](http://www.picant.com/c2c/c.html)
- Source 4 — Nuts & Volts FTP website at [www.nutsvolts.com/ftp/index.htm](http://www.nutsvolts.com/ftp/index.htm)
- Source 5 — Jameco at [www.jameco.com](http://www.jameco.com)
- Source 6 — Microchip at [www.microchip.com](http://www.microchip.com)
- Source 7 — PIC Programmer Schematic at [www2.netdoor.com/~rlang/vacutron/pic\\_prog\\_schematic.jpg](http://www2.netdoor.com/~rlang/vacutron/pic_prog_schematic.jpg)
- Source 8 — PIC Programmer Software at [www.ic-prog.com/index1.htm](http://www.ic-prog.com/index1.htm)
- Source 9 — USBCV Computer Program at [www.usb.org/developers/tools/](http://www.usb.org/developers/tools/)
- Source 10 — Cakewalk website at [www.cakewalk.com](http://www.cakewalk.com)
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## Bring Your Old Joystick Back to Active Duty

**D**o you have a PC hardware project you have been putting off because of the complexities of the USB interface? Do you have a favorite joystick you are ready to discard because it was crippled by the slow and imprecise old game port interface? Would you like a game pad with a throttle control that doesn't jump back to neutral every time you release it? You can have all these for under \$20.00.

This project adds two DB-15 connectors in the handles of a game pad. The connectors provide access to all the game pad I/O except for two tri-state hat signals. Your custom hardware can access the PC though the connectors, or override any or all of the four axes of the built-in analog controls with external potentiometers. The pinout of each connector is close enough to the standard game port that with only a minor modification, your old joysticks can be brought back to life with the speed and precision of USB (see "An Introduction to USB" *Nuts & Volts*, May 2004).

The completed project is shown in Figure 1. The number of signals provided by this modification is shown in the table below. The game pad remains fully functional except for the vibration feedback. The signals that drove the two motors become the two output signals.

Inputs	Outputs
12 digital	1 analog or digital (depends on revision)
4 analog	1 digital

Figure 1. Completed Interface.



### General Considerations

Most of the information in this article pertains to the Gamers Factory model Model G60310A. The main obstacle with modifying other game pads may be the lack of space; many are physically smaller. The method used to estimate impedances was by measuring the time interval for a capacitor to charge or discharge by two-thirds ( $r*c = t$ .) This method can be used with other game pads.

Even within the one model covered, I discovered some minor variations. There are at least two versions of the main board (see Figure 10): version 2268-01-11 (illustrated) and version 2268-01-12 with a slightly different track layout. Since the modification to the main board involves finding I/O points, this issue is easy to resolve. You can trace I/O points visually, with an ohmmeter, or by shunting points through a 1K resistor to ground while running the software test described later. Revision 2268-01-12 also adds analog control to the left motor signal and changes B9 and B10 buttons to active high.

If you plan to interface to external electronics that have their own separate power supply, the safety features described later are highly recommended. If you wish to physically incorporate the Interface within an electronics project, you only need the main board with the I/O connection points added. However, you should always perform the work bench test before connecting any of these alternatives to your PC.

### Circuit Design

Connecting two buttons in parallel creates an OR

### Abbreviations

JL	Jack Left, (DB-15 Female Connector)
JR	Jack Right, (DB-15 Female Connector)
XL	X-axis Analog Input, Left
YL	Y-axis Analog Input, Left
XRa	X-axis Analog Input, Right
YRa	Y-axis Analog Input, Right
XRb	Duplicated XR on JL (allows 4 axis control on JL)
YRb	Duplicated YR on JL (allows 4 axis control on JL)
Bx	Button x
OL	Output Left
OR	Output Right
TS-L	Thumb Stick Button Left
TS-R	Thumb Stick Button Right
CLx	Cable Left x
CRx	Cable Right x

function, which is exactly what we want to allow functioning of both the internal buttons and external connected signals. The analog inputs require more analysis but the solution turns out to be quite simple.

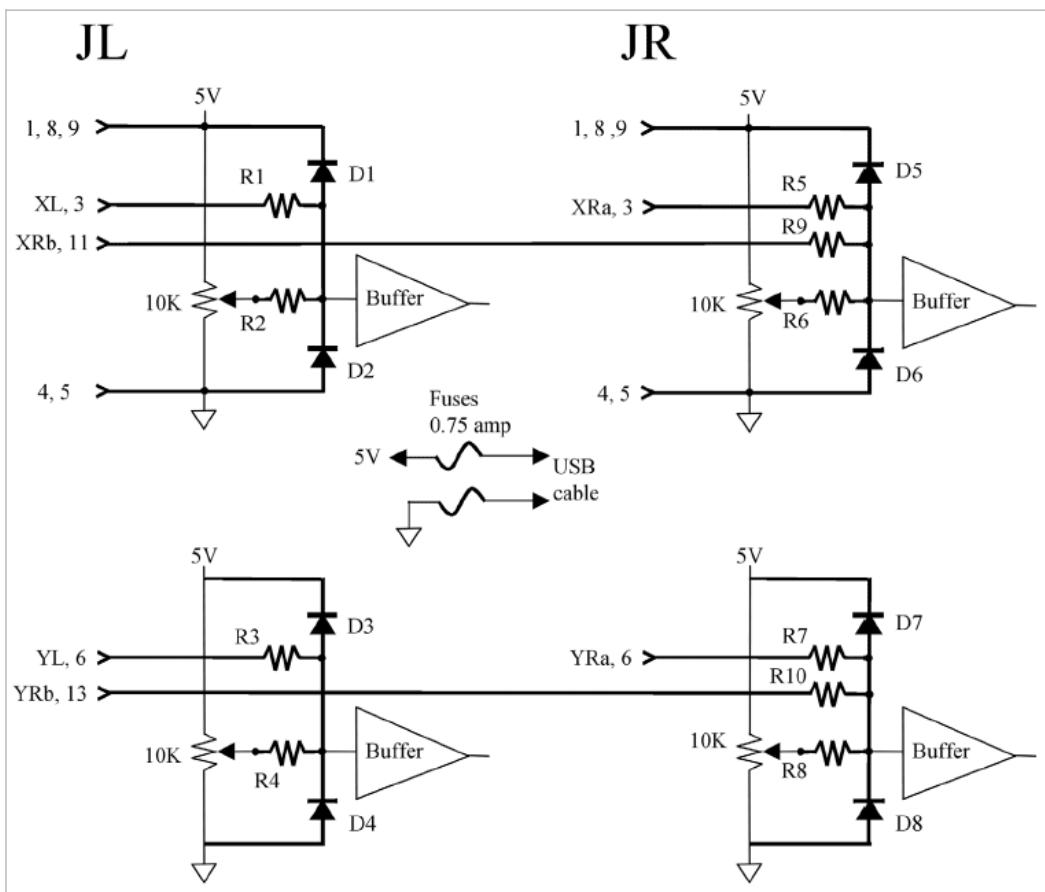
Adding isolation resistors between the internal potentiometers and buffers eliminates the need for any switches or jumpers to select the analog source. The internal game pad 10K potentiometers drive high impedance buffers. The 100K series resistors have the following effect: when no external controls are connected, the internal pots function normally; when an external pot is connected directly to a game pad buffer, it reduces the gain of the internal pot and takes control. A complete analysis is provided in the link "ControllInteraction.xls" on the *Nuts & Volts* website ([www.nutsvolts.com](http://www.nutsvolts.com)). If an analog signal is the source, it is essentially unaffected by the internal pot.

The final version added a few optional parts for safety; fuses and protection diodes across the four analog inputs. Figure 2 shows the components added to the control board in bold. Figure 3 shows the I/O connections from both boards.

## Construction

Test the game pad before starting any modification. Once the device is opened, the warranty is void. The device can be tested using a Windows built-in test as described later.

The tools I found particularly useful are shown in Figure 4. The Dremel cutting wheel provides a convenient way to cut the plastic slots for the two connectors and for cutting track. Cutouts



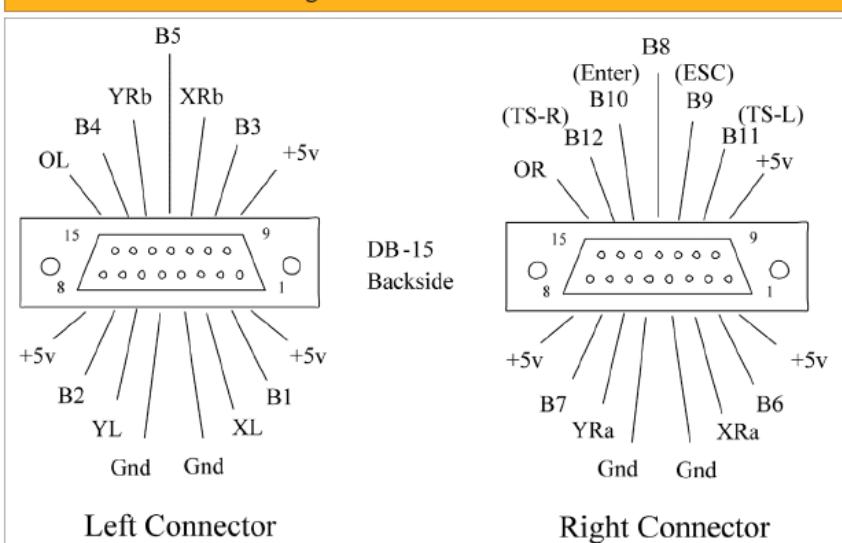
**Figure 2.** Control Board Schematic.

can be trimmed using the grinding wheels. The bit size for wiring should be about 0.035 inches as discussed in "PCB Layout Tips," *Nuts & Volts* November 2004.

## Disassembly

Disassemble the gamepad by removing the five

**Figure 3.** I/O Connections.



**Figure 4.** Recommended Tools.



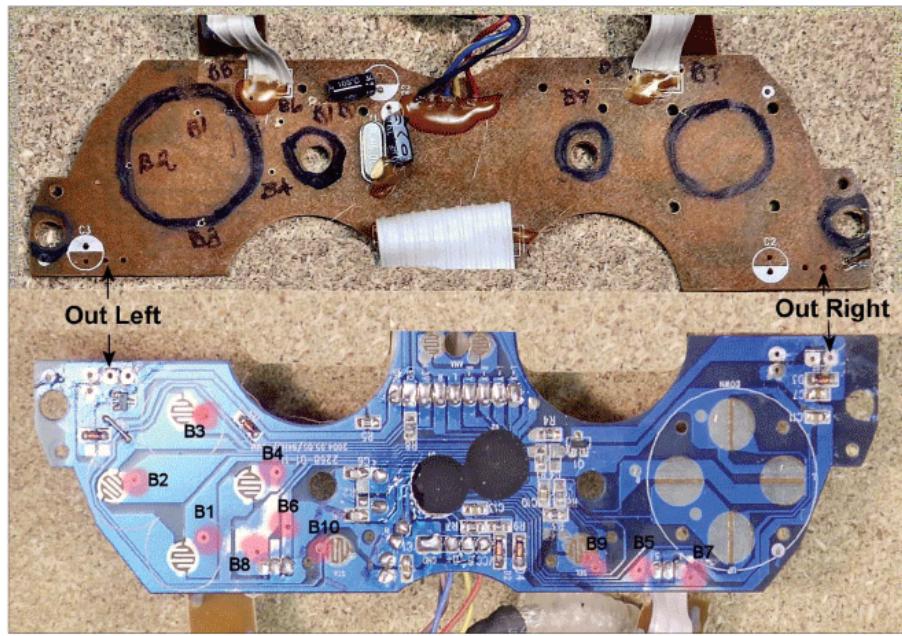


Figure 5. Main Board Modifications.

screws located on the backside. The electronics are contained in two boards wired together by a ribbon cable; the main IC board and control board. It is worthwhile to mark the location of the many mechanical obstructions to both circuit boards. After removing the cover, smear some lipstick on all the posts. Then place the cover back to leave an impression on the board.

The two motors are removed, then the two boards which are held in place by two screws each. After remov-

ing both boards from the case, you can either temporarily tie the USB cable to the main board or unsolder it to prevent damage. You can also add and leave two wires connected for workbench powering of the board until the modification is finished. You can connect these wires to the USB cable power points on the main board or to the fuse holders, if used.

## Main Board Modifications

Buttons B1-B4, B9, and B10 have test pads which can be drilled to provide I/O connection points (see Figure 5). For buttons B5-B7, holes are drilled in convenient track areas. Capacitors C3 and C7 are removed and replaced by 1K resistors to provide a faster response time for the motor output signals. Fine emery cloth is used to remove the blue protective coating.

## Control Board Modifications

Five track cuts are made to the control board as shown in the shaded areas of Figure 6. The free pad created in the middle of the board is later used as a tie point for the YL signal. A combination of six holes and slots is created in the edges of the board to fasten the tie points of the analog input resistor pairs R1-R3, R5-R7, and R9-R10. Figure 7 shows the board with added components. Jumpers on the track side of the board connect YRb, XRb, and YRa to their input resistors as shown in Figure 10. If you include the safety diodes, it is worthwhile to run a work bench test periodically to make sure a diode isn't in backwards.

## Case Modifications

The partitions that keep the motors in place are removed from both case covers. They are thin and can be cut and snapped out. Trim with grinding wheels. Figure 8 shows the location of the DB-15 connector in the top half of the case. The post on the left handle is at the correct location for the upper hole, but on the right handle the position must be measured from the lower post. The connectors were fastened with 4-40 hardware. One 6-32 nut in each mount location was used as a spacer to slightly recess the connectors.

Figure 9 shows the approximate location of the fuse holders. Try to position the fuse in the center of the concave shelf. To avoid cracking the

Figure 6. Control Track Modifications.

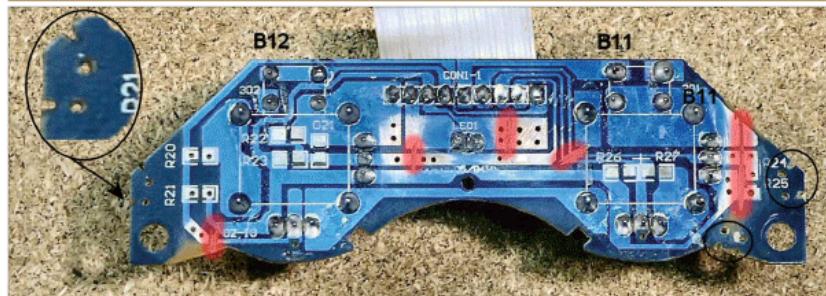
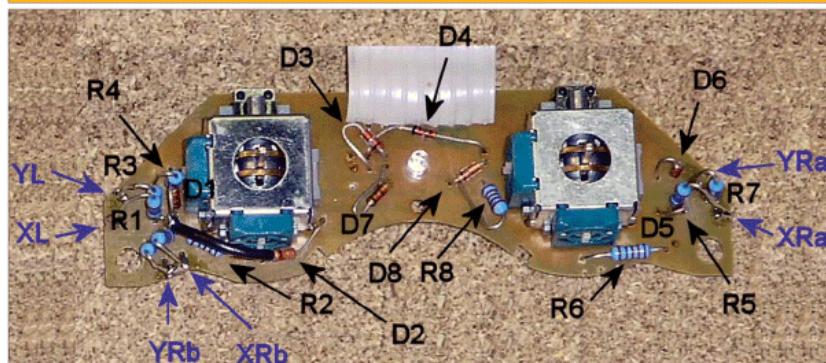


Figure 7. Wired Control Board.



case, start with a 1/8-inch bit and gradually increase the hole size. The final 1/2-inch bit should be turned by hand. After fastening the fuse holders, bend the top terminal down to increase clearance when case is assembled. If necessary, clearance can be increased further by adding a washer under the top of the fuse holder.

The cylinder on the right hand of the back cover is notched as required to avoid crimping wires when the unit is assembled.

## Cabling

Four cables were used to make interconnections with the DB-15 connectors, as shown in Figure 10. The coding used is shown in Table 1. Before assembling the case, CL1 and CR1 should be moved over the top of the main board and around the inside of the side posts. The cables can be held in place with silicon compound.

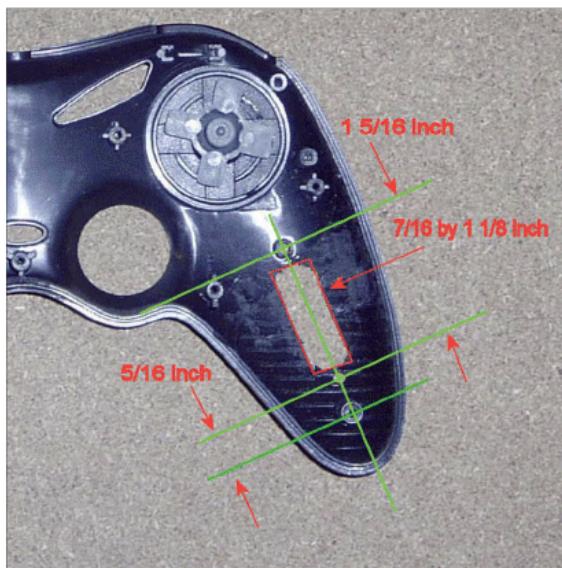


Figure 8. Connector Placement.

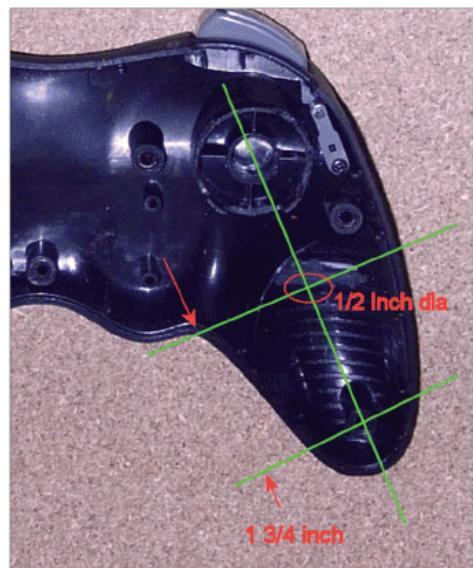


Figure 9. Fuse Placement.

## Assembly

Keeping all the cables and levers in place while the case is assembled can be tricky. By using wires to secure levers R1, R2, L1, L2 and the USB cable as shown in Figure 11, the

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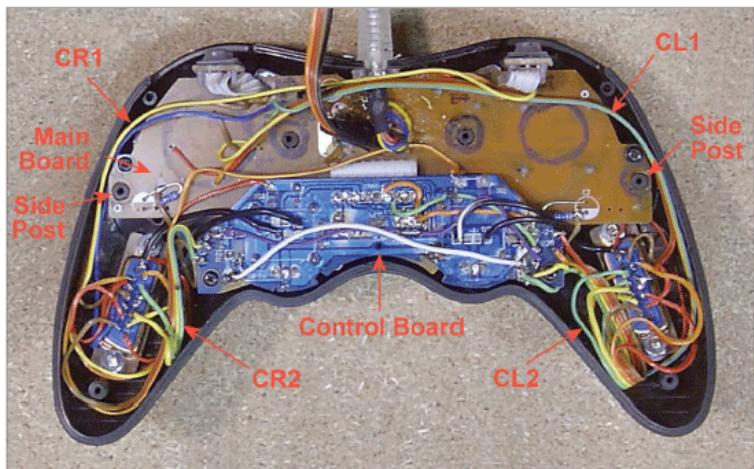


Figure 10. Interface with Cabling Installed.

task is made much easier. You then only have to make sure that the cable to the fuses is not caught under a post.

## Workbench Testing

This test makes sure you haven't made any mistakes that could damage your computer. It also aids in troubleshooting. Connect the interface to a 5V power supply

Color	CLI	CL2	CRI	CR2
Brown	B1	OL	B8	OR
Red	B2	YL	B10	YRa
Orange	B3	XL	B9	XRa
Yellow	B4	YRb	B6	B11
Green	B5	XRb	B7	B12

Table I. Cable Coding

through a 0.75 amp fast-acting fuse. With power applied and thumb sticks at neutral, check that the pot outputs and buffer inputs are about one-half the supply voltage. Next, check that the voltage at these points varies as you move the thumb sticks. Then use the mode button to place the game pad in analog mode. The LED should light. If all this works, then you can proceed to PC Testing.

## PC Testing

Windows 2000 and Windows XP include a built-in test program for USB controllers. These will work fine even without the Gamers Factory software installed. To test the thumb sticks, place the Game Pad in analog mode by pressing "Mode."

### Parts List

Gamers Factory USB Game Pad  
2 — DB-15 female connectors  
2 — Fuse 0.75 amp  
2 — Fuse holder  
4 — 100K resistors (R2, R4, R6, R8)  
8 — 1K resistors (all others)  
Ribbon or jacketed cable  
Misc hardware

Best Buy Model: G60310A  
MCM Electronics, part no. 83-230  
MCM Electronics, part no. 28-285, RadioShack 270-1048  
MCM Electronics, part no. 28-0175, RadioShack 270-362  
RadioShack, Digi-Key, MCM Electronics  
RadioShack, Digi-Key, MCM Electronics  
RadioShack, Digi-Key, MCM Electronics  
Home Depot, Lowes, RadioShack

### For Windows XP:

Click on Start, Control Panel, Printers and Other Hardware, Game Controllers, Properties.

### For Windows 2000:

Click on Start, Settings, Control Panel, Gaming Options, Properties.

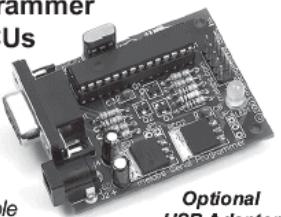
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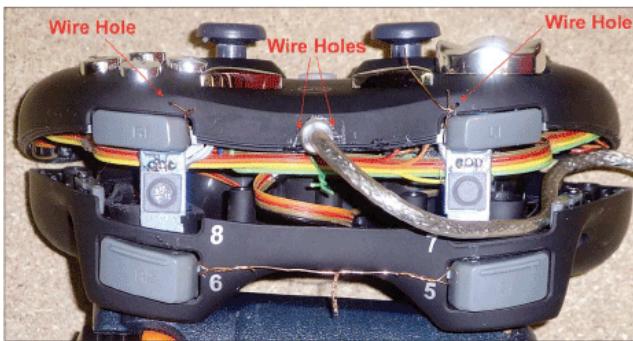
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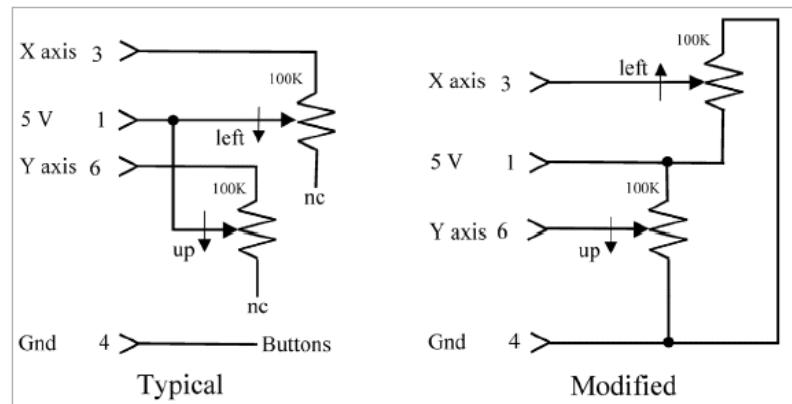
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**Figure 11.** Assembly Aids.



**Figure 12.** Joystick Modification.

## Using the Interface With Joysticks

The old style joysticks require a simple modification to be used with the Interface. The potentiometers need to have a ground connection, as well as five volts, as shown in Figure 12. Note that the five-volt connection to the X-axis pot is reversed. Some joysticks have additional analog controls called X2 and Y2. If you modify these potentiometers in the same way, they will be functional. You can connect one joystick with X2 and/or Y2 controls to the left connector, or two joysticks without extra controls.

## Using the Interface With Custom Controls

The game pad analog controls can be individually overridden by external potentiometers in the 10K to 100K range. One purpose would be to create a more useful throttle control that doesn't automatically return to neutral when released. Or you could substitute your own foot pedals or a steering wheel for an internal analog control. Similarly, you can add any of the 12 digital controls to a custom controller by wiring your own buttons to the appropriate pins. In addition, a repeater function can easily be added with a 555 timer.

## Using the Interface With Custom Electronics

The analog inputs have an impedance of approximately 100K that is easily driven by any IC device. The button inputs have pull-up resistors of about 7K which can be driven by almost any logic gate family. Some applications for custom electronics might be data logging of temperature, power consumption, or speed over long periods of time, or remote control of a PC. Including a final driver stage that uses the gamepad 5V in your project will reduce the chance of accidental damage to a PC.

### About the Author

Larry Brooks has a Masters in EE from Loyola College. He has many years of professional experience working as both a hardware design engineer and programmer.

## Future Work

An article is planned to show you how to talk to the Interface through your own Windows program using Microsoft's Direct Input API. In that article, a program will be developed that can be used to test the maximum throughput of the digital inputs and maximum slew rate of the analog signals. In the meantime, I hope you come up with some other neat applications for this low-cost interface. And please share them with other *Nuts & Volts* readers. **NV**



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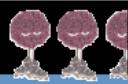
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# The Ultimate Utility Meter

## Part 2 — Operation

Last month, we assembled and tested our Ultimate Utility Meter (UUM). This month, I will show you how to operate the UUM.

### UUM Operation

First, let's go over the keys on the keypad. Some keys have a specific purpose depending on which command is active.

#### Cursor Keys

The logic analyzer has two cursors. You move Cursor 1 using the keys 1 and 3. Think of Cursor 2 as a reference cursor. It is set by hitting the 2 key. The difference between the cursors is always displayed on the display shown in Figure 3.

#### Page Keys

The logic analyzer always captures four pages of data. To move between the pages, use the INC Page and DEC Page keys shown in Figure 2. Notice that Cursor 2 always stays where you set it. Cursor 1 moves with the page. This way, you can take measurements between pages.

A small black bar will move indicating the current page you are on, as shown in Figure 4.

#### Scale Key

The scale key allows you to change the resolution of the next capture. The scale shown in Figure 5 displays the number of microseconds for each pixel.

Note that this is the smallest point of resolution of the current capture. The following scales are supported:

- 1.7 uS
- 3.0 uS
- 4.3 uS
- 5.7 uS
- 7.8 uS
- 13.4 uS
- 24.5 uS
- 48.2 uS
- 86.0 uS
- 200 uS

#### Capture Data Key

This key will start a data capture. If triggers are used, it will wait until the trigger condition has been set. You can hit the key if you wish to exit the capture mode.

#### Command Keys

The command keys allow you to change other parameters or issue certain commands. The active command/parameter name is displayed as shown in Figure 6.

Once a command is selected, the 7, 8, and 9 keys are used to change the values or execute the command.

Let's take a look at each command or parameter in detail.

#### Delay

This command (Figure 6) will allow you to insert a

Figure 1. The completed project.



Figure 2. The keypad.

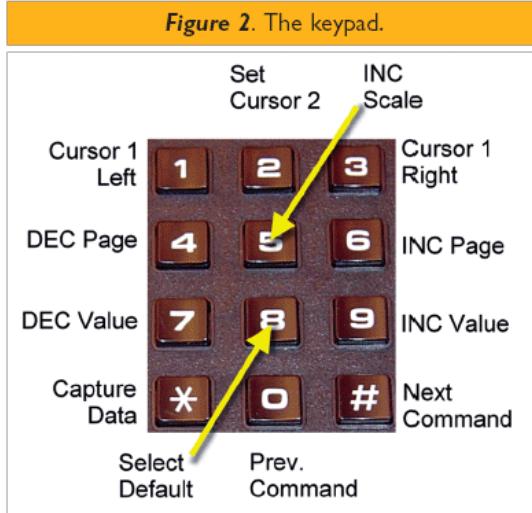


Figure 3

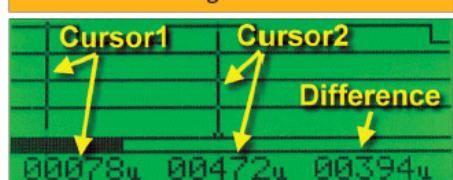
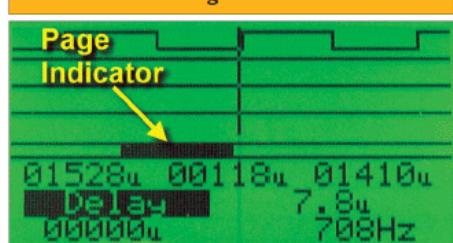
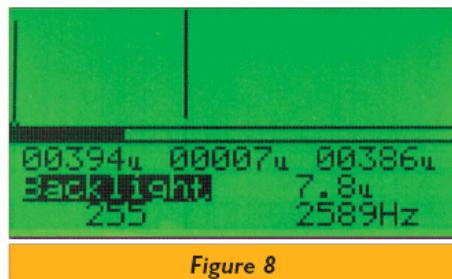
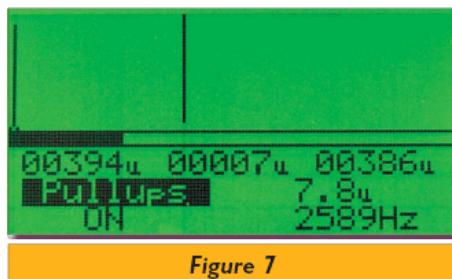
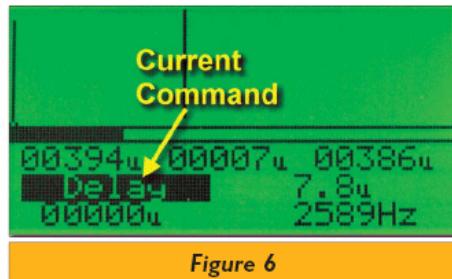
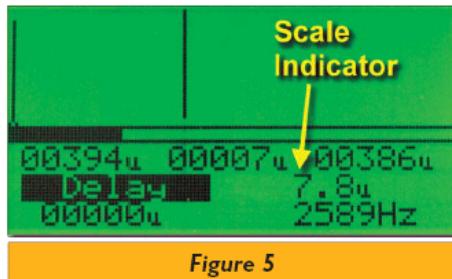


Figure 4



# Project



delay before the logic analyzer starts the actual capture. Use the 7 and 9 keys to change the value. The 8 key sets the value to 0.

## Pullups

This command (Figure 7) allows you to turn weak pull-up resistors on or off on all the analyzer ports. Use the 8 key to toggle on and off.

## Backlight

The backlight command (Figure 8) allows you to set the intensity of the back light. Use the 7 and 9 keys to change the value. Use the 8 key to set it to 200.

## Channels

There are three display modes for the logic analyzer. You can display all eight channels as shown in Figure 10 or select channels 0-3 or 4-7 as shown in Figure 9. When

as well.

## Edge Trigger

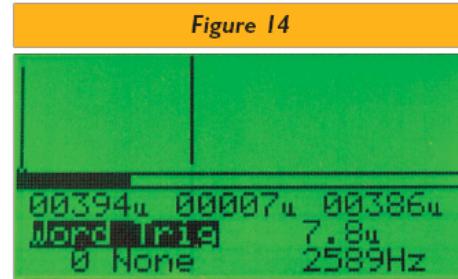
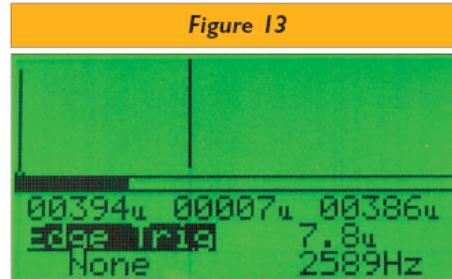
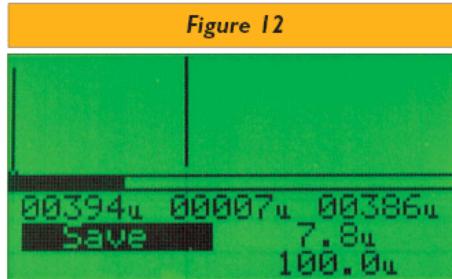
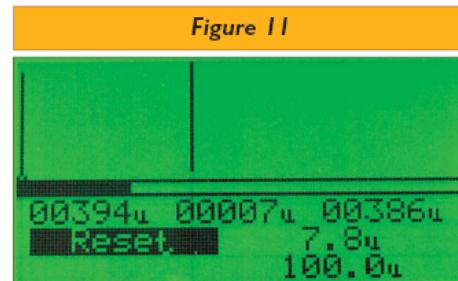
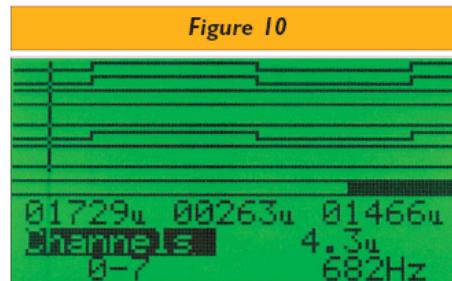
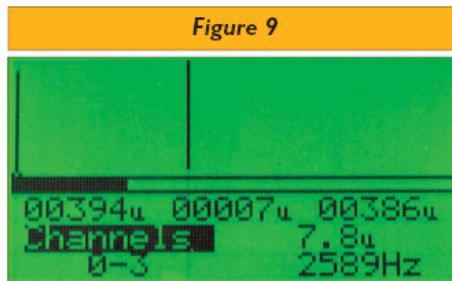
Here you can set one of the channels as an edge trigger. This normally is used to monitor a single repeating signal. It will wait one complete cycle, then trigger on the low-to-high or high-to-low, depending on which is selected.

Using the edge trigger will turn off the word trigger if it has been activated.

Use the 7 and 9 keys to select the channel and the 8 key to toggle the low-to-high or high-to-low transition. If no trigger has been set up, the word none will be displayed as shown in Figure 13.

## Word Trigger

This command (Figure 14) will allow you to set a condition on any of the eight channels. You can set each channel to Low, High, or None. If set to None, that



you only need a couple of channels, the 0-3 or 4-7 channel options are much easier to see.

You can change the channels at any time. The current capture data will be redrawn.

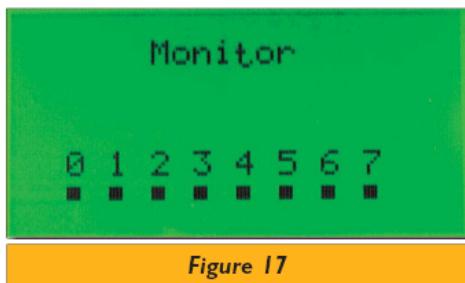
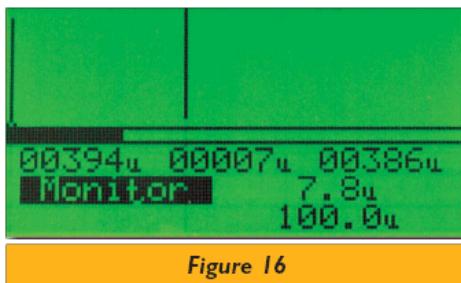
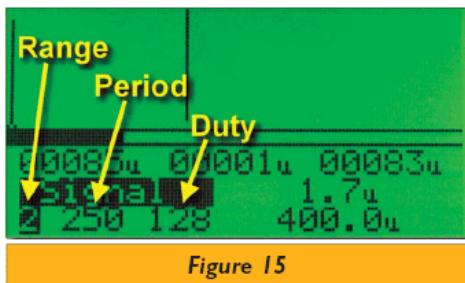
## Reset

This command will reset both the graphic serial LCD and the controller. The 8 key will do the reset.

## Save

This command allows you to save all the current parameters so that they will be loaded the next time you start the UJM.

Use the 8 key to save. Cursor location and scale settings are saved,



channel will be ignored for the trigger condition.

When you start a capture with the \* key, the analyzer will wait until all the channels are in the trigger condition. Once the conditions have been met, the delay — if set — will be activated; then the capture will start.

Change the channels with the 7 and 9 keys, then use the 8 key to toggle between the Low, High, and None conditions. If you don't wish to use any trigger condition, set all channels to None.

## Signal

This command (Figure 15) will allow you to change the value of the built-in pulse generator. Use the 8 key to jump between the three parameters, and the 7 and 9 keys to change the values.

### Valid Ranges

Range 0: .1 uS to 25.5 uS in .1 uS increments

Range 1: .4 uS to 102 uS in .4 uS increments

Range 2: 1.6 uS to 408 uS in 1.6 uS increments

The output is placed on Port 13. It is marked Signal on the schematic.

## Monitor

The monitor (Figure 16) is used as a logic probe to monitor eight ports at one time. Use the 8 key to activate the monitor.

Once activated, the monitor screen will be displayed, as shown in Figure 17.

A dark square indicates a logical 1, and an empty square indicates a logic 0. A small arrow will point to the ports that have changed recently.

To exit the monitor, just hit the \* key.

## Analyzer Examples

### 1Wire

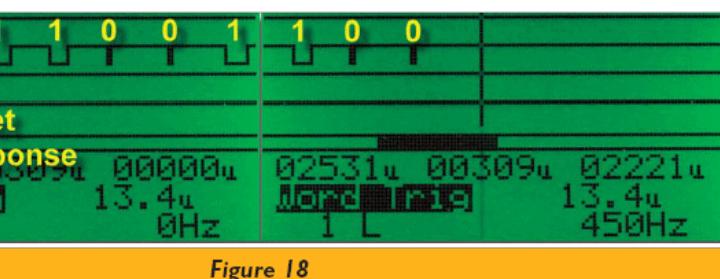
Here, I set port 1 on the analyzer to monitor the data channel on a 1Wire device. This captured sequence shows the 1Wire reset and a byte of 170 (\$CC) being sent.

Figure 18 shows two of the captured pages. Notice

that the Word Trigger for Port 1 has been set to low. This means that once started, the analyzer will wait until it sees the port go low.

### Serial

In this example (Figure 19), I set Port 1 to monitor the output of a microcontroller I/O port as it sends the value



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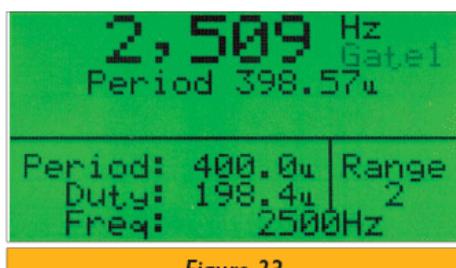
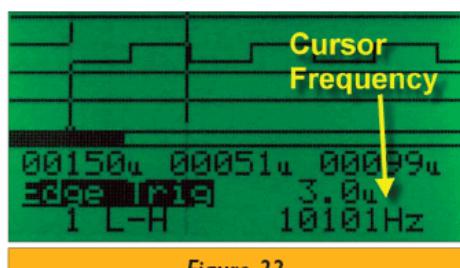
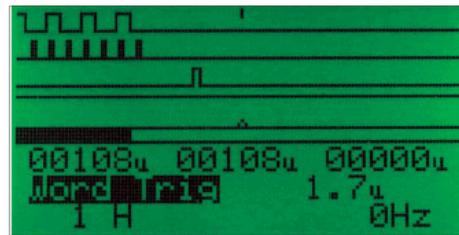
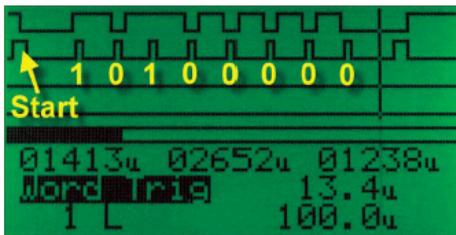
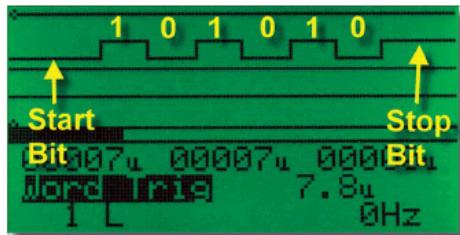
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# Project



of 170 at 9600 baud 8n1. Again, the word trigger for Port 1 is set to low.

## I2c

This is an I2c control byte (Figure 20). The SDA line is on Port 0, the SCL line is on Port 1. You can see the start sequence followed by the control byte of 160.

## SPI

This is the three control lines connected to a 74HC595 serial shift register (Figure 21). Port 0 is connected to the Serial In line. Port 1 is connected to the Clock line. Port 2 is connected to the Latch line.

One thing I noticed is that the SPI interface is the fastest interface shown. In most cases, it is very difficult to capture the clock pulses as they can be quite fast.

## Pulse

For a repetitive pulse train, use the edge trigger so that the pulse train will start at the same point at each capture.

In this example (Figure 22), I took the signal line (Port 13) and connected it to Port 1. I set the Edge Trigger on Port 1 to L-H. The signal generator is set up to send a 100 uS pulse at a 50% duty cycle.

Notice that as you move the cursors it will display the calculated frequency based on the period measured.

## Extra

I have written a little program I call Frequency Counter as an example of the kinds of programs you n write.

The program is located in the projects/UUM directory and is called FreqCounter.txt. Program this into the

controller (prog/debug 2). Make sure you still have the Serial LCD on the first controller.

This is a frequency counter with three automatic gate ranges. It also gives you access to the signal generator. The input to the frequency counter is on Port 15. The output of the signal generator is on Port 13.

## Final Thoughts

### Pods

I create small pods that connect to the exposed headers. These are nothing more than small female headers with leads or components connected to the pins. These pods are removable so that I can add other pods for other experiments. For instance, I have a small pod with a DS1820. This gives me a very accurate temperature gauge that I can use to calibrate other projects.

### Software Upgrades

Since the UUM is programmable, you have total control of the UUM. This project promises to be very popular and a frequently updated one, so visit the Kronos Robotics website often for updates and additional information.

### Hardware Upgrades

These are unlimited. I added a larger base so I could attach a breadboard. I also added a reset button. Another easy upgrade would be to use a DiosPro in place of the standard Dios Chips. NV

## Links

Kronos Robotics  
[www.kronosrobotics.com](http://www.kronosrobotics.com)

UUM forums  
[www.kronosrobotics.com/forums/  
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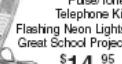
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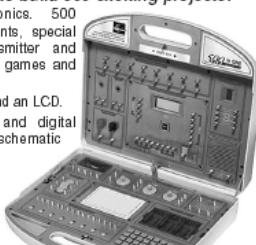
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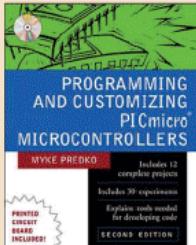
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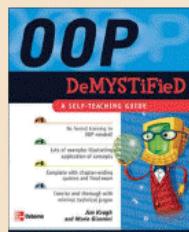
This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicros' hardware architecture and software schemes will complement the host of experiments and projects making this a true "learn as you go" tutorial. New sections on basic electronics and basic programming have been added for less sophisticated users, along with 10 new projects and 20 new experiments. The CD-ROM contains all source code presented in the book, software tools designed by Microchip and third party vendors for applications, and the complete data sheets for the PIC family in PDF format. **\$49.95**



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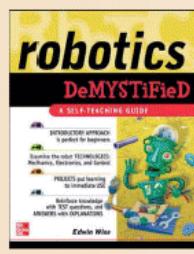


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### Robotics Demystified

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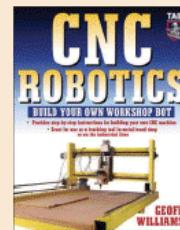
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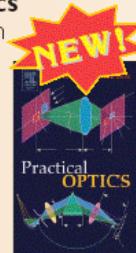


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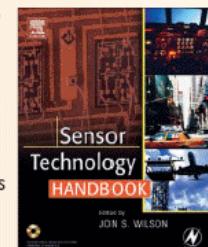
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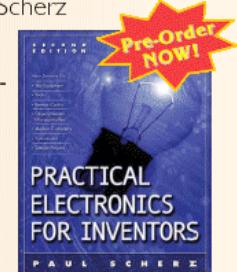
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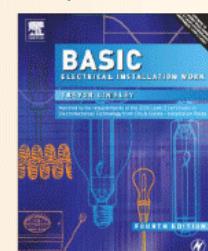


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## Basic Electronics

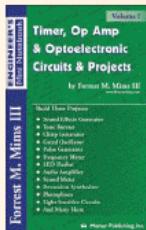
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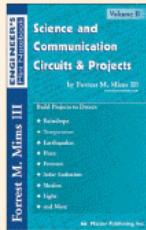


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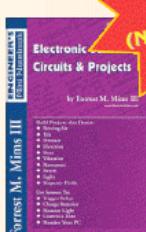
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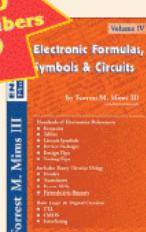


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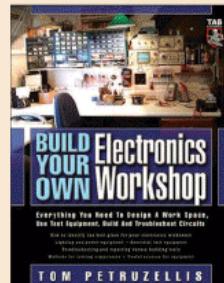
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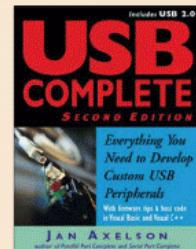


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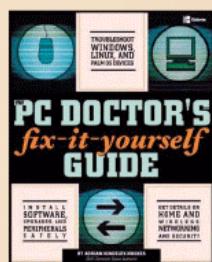
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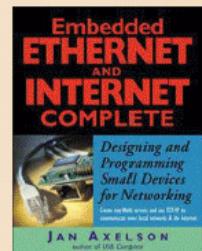


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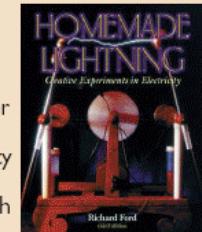


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# WIRESPONDENCE!



## Imagine a world without the Internet:

no email, no chat sessions, no Usenet newsgroups, no Web. This is the world of 1951. A citizen of this world who wanted to discuss common interests, politics, or world events with others on a national or international scale had few channels to communicate through.

by David Medcalf

**O**ne promising channel was ham radio. Unfortunately, this method required an FCC license, an antenna, and the technical know-how to operate and maintain the transmitting equipment. Long distance phone calls didn't require specialized knowledge, of course, but in 1951 a call from Chicago to St. Louis cost 30 cents per minute. This was expensive, being equivalent to \$2.19 per minute in today's dollars.

Letter writing was not yet a dying art in 1951, but, just as with email today, letters lacked the expression of voice (the smiley face, ubiquitous in today's email, had yet to be invented). Voice recordings were a more powerful alternative, and inexpensive compared to long

distance calls.

By 1940, consumers could create their own sound recordings using record cutting machines. Portable units were available, combining the record cutter with a regular phonograph and radio. Record blanks were made of acetate or lacquer-coated metal disks and, by 1950, could hold up to 40 minutes of speech and music. Messages could be sent to anyone who had a record player, from family and friends, to servicemen overseas. Unfortunately, record cutters were write-once devices — once the disk was cut, no changes could be made to the message.

The magnetic wire recorder, ancestor to the tape recorder, had undergone great development during World War II. By the late 1940s, wire recorders

**Photo 1.** A wire recorder is sitting on the desk to the left. This exhibit is dedicated to the Roswell Incident of July 4, 1947, at the International UFO Museum and Research Center in Roswell, NM. Photo courtesy of the International UFO Museum and Research Center.



**Photo 2.** Model 181, to the left, cost about \$100.00 and featured a Magic-Eye tube as a recording level indicator. Model 228, to the right, was designed for business dictation. Webster-Chicago made several variations of its basic models. These units, and the Silvertone models shown elsewhere, are on display at the Museum of Radio and Technology, Huntington, WV. Photo courtesy of Richard Post.





**Photo 3.** This is a Silvertone combo unit, manufactured by the Colonial Radio Corporation for Sears, Roebuck and Company. The rim of the turntable acts as the takeup reel for the wire recorder. Photo courtesy of Richard Post.



**Photo 4.** This is the wire recorder portion of a Silvertone console unit, containing a separate phonograph and radio. The recorder could be controlled by the clock/timer on the front, allowing radio programs to be recorded while the listener was absent. Photo courtesy of Richard Post.

were available in consumer equipment. Sears, Roebuck and Company sold at least two "Silvertone" combination models that included a wire recorder, phonograph, and radio. Wire recorders solved the editing problem inherent with cutting records, as parts of messages could be deleted or recorded over. Playback quality could be checked while a recording was being made, and separate wire recordings could be spliced together, as well. A spool of stainless steel recording wire was more expensive than a record blank, but could

## RESOURCES

During the 1940s and 50s, the wire recorder gained popularity as a tool for news reporters and as an entertainment device for consumers. These machines can now be found occasionally at ham-fests and on online auction sites. Advice for repairing recorders and splicing wire recordings can be found at the Video Interchange website:

[www.videointerchange.com/wire\\_recorder1.htm](http://www.videointerchange.com/wire_recorder1.htm)

Webster-Chicago was a major manufacturer of wire recorders from the mid-40s to the early 50s. Schematics and period prices of their major models can be found at:

[www.webster-chicago.com](http://www.webster-chicago.com)

Recording wires were commonly made of stainless steel, and so many recordings have survived to the present. Examples that have been converted to MP3 format are available at:

[www.coolcatdaddy.com/rand/wires.html](http://www.coolcatdaddy.com/rand/wires.html)

hold over an hour of audio.

Recording a message on a wire spool and mailing it off to family and friends became a growing fad called "wirespondence." Webster-Chicago, a company that produced audio equipment including wire recorders, created the Wirespondence Club in 1950. This effort was spearheaded by John Schirmer, an employee of Webster, who saw the power of corresponding by audio recordings. In 1948, the Soviet Union blockaded West Berlin where Schirmer's mother lived. During the massive US and British airlift supply campaign, one of the pilots ordered a wire recorder from Webster. Schirmer, being in the export

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**Photo 5.** This is a Webster-Chicago Model 80, one of the most popular wire recorders available in the late 40s. It originally retailed for around \$150.00. The stainless steel recording wire is extremely thin and could kink into a tangled mess easily. To help prevent this, the recording head oscillates vertically to bail the wire smoothly onto the reels. Photo courtesy of the International UFO Museum and Research Center.

department, recorded a 15 minute message for his mother and shipped the spool along with the recorder. Thanks

to the pilots, a flow of recordings to and from blockaded Berlin began.

In the first three months of the formation of the Wirespondence Club, membership had reached 830, with members representing 20 countries besides the United States. By late 1952, the Club had grown to over 1,900 members from 35 countries and all 48 states (Alaska and Hawaii had not yet achieved statehood). Members came from all walks of life, including scientists, ministers, farmers, artists, and bankers. Topics of interest were wide-ranging, involving politics, language, music, and descriptions of the scenery in the sender's local area.

At least two marriages are reported as having originated from wirespondence (just as has resulted from Internet chat sessions today). Municipal and religious leaders of Springfield, MA, sent a spool of friendly greetings to the townspeople of Shiremoor, Northumberland, England, as an expression of fellowship to members of our World War II ally. A wirespondent told a United Nations *World Magazine* reporter, "You learn to understand and like people of different background. Your horizons extend and you lose the idea that your country and your way of living is the only one."

The constant desire to communicate continues to drive our technology forward. **NV**

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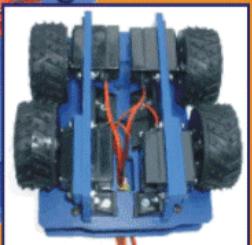
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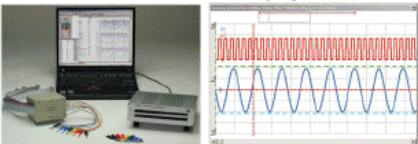
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# Taking the Teeth Out of Bluetooth Phracking



THE CRYPTOPHONE PSTN/1, GSMK'S SECURE LANDLINE PHONE THAT IS FULLY INTEROPERABLE WITH GSMK'S SECURE CELLULAR AND SATELLITE PHONES.

**Paris Hilton's hijacked phone notes, hot pics and movies, and celebrity contact info got her unwanted and undeserved notoriety. The incident also brought broad visibility to a blossoming dilemma: like computer data, our increasingly computer-like mobile phones' contents can be hacked.** *by David Geer*

**T**o be correct, your data can be phracked. Phracked, phracking, or phracker are the correct terms for a phone cracker or phone cracking. Cracking is the correct term for malicious hacking.

Following the classic security mantra of using layered protection, we present several counter-hacks that untethered communicators can use to foil the would-be phracker.

## BLUETOOTH SECURITY — BLUETOOTH BACKGROUND

Bluetooth is a fairly recent technology that has faced its share of invasions. Notable attacks have included Blue Stumbling, Blue Snarfing, and Blue Jacking.

Blue Stumbling is the Bluetooth equivalent to War Driving\*. By using Blue Stumbling, phrackers (phone

crackers) can pinpoint Bluetooth gadgets (PDAs, Mobile Phones) within a small radius.

*(\*With War Driving, a cracker drives around with a laptop and a special antenna engineered from a potato chip cylinder discovering unprotected Wi-Fi networks. Wi-Fi crackers do this so they can use your connection for free, crack another system through your connection while masquerading as you to steal data or deface websites, or simply mess with your head.*

*Blue Stumbling is also referred to as War Walking.)*

Blue Snarfing is a technique that permits a phracker to rob data from your Bluetooth device without pairing (making a direct connection) with it. Phrackers cannot only surreptitiously retrieve information from your Bluetooth device, but also send information to it without exposing themselves or having to be acknowledged by the recipient.

With Blue Jacking, phrackers can send information to the Bluetooth device without pairing with it so that you wouldn't know who it was from. It's a kind of Bluetooth-based version of spamming.

## BOUNCING BLUETOOTH BREAK-INS

For most all the above, protection is as easy as downloading and installing the latest firmware update for your phone. Other fundamental precautions include turning off the Bluetooth service when you're not using it. If it's not running, it can't be hacked.

Insure that your phone has encryption abilities and use them. Some brands offer seamless encryption that's always on to protect your Bluetooth connections so you never have to set it (check the manual for your hardware). Nokia is such a vendor.

With Nokia Bluetooth enabled phones, the encryption is transparent to the user, always on, automatically protecting authenticated Bluetooth connections, including voice communications between a headset and phone.

Use the phone in non-discoverable mode (see your manual). When any Bluetooth device is in non-discoverable mode, it can't enter into a state where it can respond to inquiries. You can loosely think of it like not hav-



ing your wireless 802.11 router set in broadcast mode.

Create new link keys for pairing with other devices. With Nokia phones, you can create a new link key for pairing devices by deleting the existing pairing from the paired devices menu. This keeps the passkey new and unique, harder to crack.

You can also audit your phone — test its security — using Bluetooth network discovery tools like BlueSniff and RedFang. With these software downloads

LEFT: The GSMK CryptoPhone 200, the world's first secure PDA-based cellular phone.

BELOW: The CryptoPhone 200T, GSMK's secure phone for both cellular and satellite connections.



and most any Bluetooth adapter, you can use a simple interface to check for the availability of Bluetooth networks and devices (including your own).

## OTHER SECURITY MEASURES – AV AND FIREWALLING

Bluetooth is by far the only phone protocol or the only phone vulnerability. For advanced devices, firewalls and antivirus protection are recommended. Using Nokia as an example, you can use products such as Symantec's integrated firewall and AV product for Nokia's 9500 Communicator and the 9300.

Both F-Secure and Symantec offer AV for the Symbian OS-based Nokia smart phones, i.e., Symantec Mobile Security 4.0 for Symbian protects Symbian operating system based smart phones (series 60 and 80) like the 9300 and 9500 from not only viruses, but also Trojans and worms. Comparable information should be available from your vendor.

## MORE FROM NOKIA

Don't accept unidentified Bluetooth applications or MMS attachments. These may include phone-based malware that is harmful to your phone. Don't download content to your mobile phone from an unknown, obscure, or unreliable source. Download from your operator's (carrier's) portals or other well-known brands, where you should assume good protection against potentially harmful malware (viruses and the like).

Nokia has a VPN solution for many of its smart phones at [www.nokia.com/nokia/0,,43117,00.html](http://www.nokia.com/nokia/0,,43117,00.html). A wallet feature available in many Nokia models secures sensitive e-commerce and other data. Data inside the wallet is encrypted and protected with a special access code that the phone user can define. See more at: [www.nokia.com/nokia/0,8764,43153,00.html](http://www.nokia.com/nokia/0,8764,43153,00.html)

## >>>RESOURCES

THE CRYPTOPHONE G10, THE WORLD'S SMALLEST, LIGHTWEIGHT TRI-BAND SECURE GSM PHONE.



### ■ RAZORPOINT SECURITY TECHNOLOGIES [www.razorpointsecurity.com](http://www.razorpointsecurity.com)

Thanks to Gary Morse, president of Razorpoint, for his input on Bluetooth.

### ■ NOKIA [www.nokia.com](http://www.nokia.com)

Thanks to Nokia for its input on Nokia mobile phone security.

### ■ GIZMODO, THE GADGETS WEBLOG [www.gizmodo.com](http://www.gizmodo.com)

### ■ BLUETOOTH WEBLOG <http://bluetooth.weblogsinc.com>

### ■ BLUESNIFF <http://bluesniff.shmoo.com>

A Bluetooth network discovery tool

### ■ REDFANG [www.securiteam.com/tools/5JP0I1FAAE.html](http://www.securiteam.com/tools/5JP0I1FAAE.html)

Another discovery tool

### ■ MISC. BLUETOOTH SECURITY RESOURCES [http://wiki.mediaculture.org.au/index.php/Bluetooth\\_Security](http://wiki.mediaculture.org.au/index.php/Bluetooth_Security)

### ■ BLUEZ.ORG [www.bluez.org](http://www.bluez.org)

The Linux Bluetooth Protocol Stack

## OR, JUST GET A PHONE BUILT AROUND SECURITY

The new CryptoPhones from Germany in four models are all about cryptography and security. The devices use AES256 (Advanced Encryption Standard) and Twofish algorithms for security and the 4096 bit Diffie-Helman key exchange technology.

The US Government has approved AES encryption for up to and including classified top-secret information. The 256 stands for 256 bits, the largest number of bits available to encrypt data. Twofish encryption was a top finalist for selection as the AES standard, beat out by Rijndael encryption.

The Diffie-Helman is based on RSA (the RSA algorithm invented by Ron Rivest, Adi Shamir, and Leonard Adleman, the acronym being formed by the first letters of their last names) math and enables secure key exchanges where the encryption and decryption key is the same exact key.

The CryptoPhone destroys its encryption key automatically the second the call ends. Standby time is a competitive 180 hours. Talk time using security is up to 3.25 hours on a single charge. The CryptoPhone supports GSM networks.

The CryptoPhone offers a hard line defense in the face of IMSI-catchers (IMSI stands for International Mobile

---

**DON'T ACCEPT UNIDENTIFIED BLUETOOTH APPLICATIONS OR MMS ATTACHMENTS. THESE MAY INCLUDE PHONE-BASED MALWARE THAT IS HARMFUL TO YOUR PHONE.**

---

Subscriber Identity) and network-based interception threats. An IMSI Catcher is a device for finding mobile phones (short range) and recording telephone calls. The device appears to the mobile phone to be just another base station.

The phone provides CELP (the Code Excited Linear Prediction algorithm) voice quality and you can use a free GSMK CryptoPhone for Windows client to set up secure telephony between a landline user or users and the mobile GSM CryptoPhone 200 using a computer and modem. The format and form factor resemble PDA-phones with a large display and easily maneuvered interface.

Because the phone software is based on open source code, there is no proprietary control that might create its own security issues, i.e., there is nothing concealed from the user -there are no backdoors, no operator (carrier) key generation, or registration.

The CryptoPhone is the only mobile phone on the market with the full source code published. This enables engineers and programmers to assess its security independently. If you're a developer, you can develop your own CryptoPhone compatible products using the published source code and the public, standards-based communication protocols. **NV**

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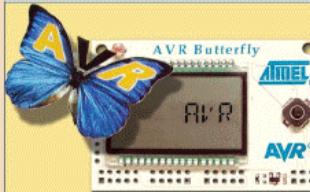
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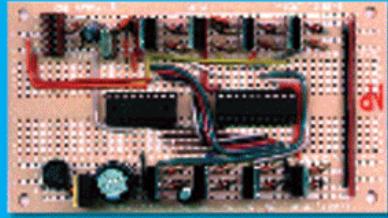
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# Reader Feedback

(Continued from page 6)

scribers. Even so, one would likely be correct in assuming even they subscribe because of the hobby aspect of the magazine.

Many in the electronics field are called nerds, for good reason. They love what they do enough that they do it not only in their professions, but are also tinkerers at home.

What would be the fun in buying commercially-available units when one can build things, create working products with one's own hands?

Why would anyone subscribe to NV if they thought of constructing electronics projects as being a chore, or not something enjoyable to spend time upon? It seems, to me,

almost incomprehensible.

**Charles Rhines  
Sioux Falls, SD**

*Dear Nuts & Volts:*

First of all, I must say that your magazine is a great magazine. It covers both projects and up-to-date market information related to electronics which is a must for people who want to keep abreast with the latest info available.

What I really want to compliment is, the people of *Nuts & Volts* really listen to their customers. I sent a suggestion to NV about distributing the great magazine in digital format and, Viola! I got it.

**Davis Hong**

*Dear Nuts & Volts:*

As a long time reader, and a subscriber for a few years, NV is my favorite magazine.

As a teacher, I find the articles useful in keeping up with advances in the field and the circuits are especially helpful in teaching our circuits, programming, and fabrication classes.

I am always looking for articles that help me teach topics that are "cutting edge" and not usually found in other typical electronics literature. Thank you for a truly useful magazine!

**Joe Sloop  
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## EU Proposes System for On-line Music

The European Commission has proposed a single Europe-wide copyright and licensing system for on-line music to boost the European Union's music business.

EU Internal Market Commissioner Charlie McCreevy said European on-line services had to be improved to make copyrights cheaper for artists to obtain.

"We have to improve the licensing of music copyright on the Internet," McCreevy said, adding such a system would ensure "Europe's creative community will get the lion's share in revenues achieved on-line."

Currently artists have to secure copyrights in each of the EU's 25 member nations, with each country requiring separate copyrights for the right to transmit songs over the Internet, a complex and expensive process, the EU head office said.

As a result of these costs, on-line music sales in Europe have lagged behind those in the United States. Last year, the US had an estimated \$248 million in on-line music sales compared with Europe's \$32.5 million.

Musicians make money from their music after registering copyrights with collective rights managers. Those managers then license songs to on-line services, radio stations, dance clubs, and other outlets. All these registrations are complex and cost artists a lot of money.

The EU head office said a single system governing music rights would save money.

"The most effective model for achieving this is to enable right-holders to authorize a collecting society of their choice to manage their works across the entire EU," said the Commission in a statement, adding such a system would "considerably enhance" earnings for artists.

## Sasser Creator Avoids Jail Term

A German youth has been given a 21-month suspended sentence after being convicted of creating the Sasser worm which crippled computers worldwide.

Sven Jaschan was found guilty of computer sabotage and illegally altering data, said a court official.

He evaded a jail term as he was tried as a minor since he was 17 years old when he wrote the worm.

Sasser wrought havoc when the Windows worm struck in May 2004, swamping net links and making computers unusable. Jaschan had admitted to creating the worm at the beginning of his trial, reiterating a

confession to authorities at the time of his arrest in May 2004.

## Keystroke Logging a No-No in Alberta

A Privacy Commissioner's ruling against an Alberta library that electronically monitored an employee's computer use means employers have lost one objective way of measuring workers' performance, says the library's director.

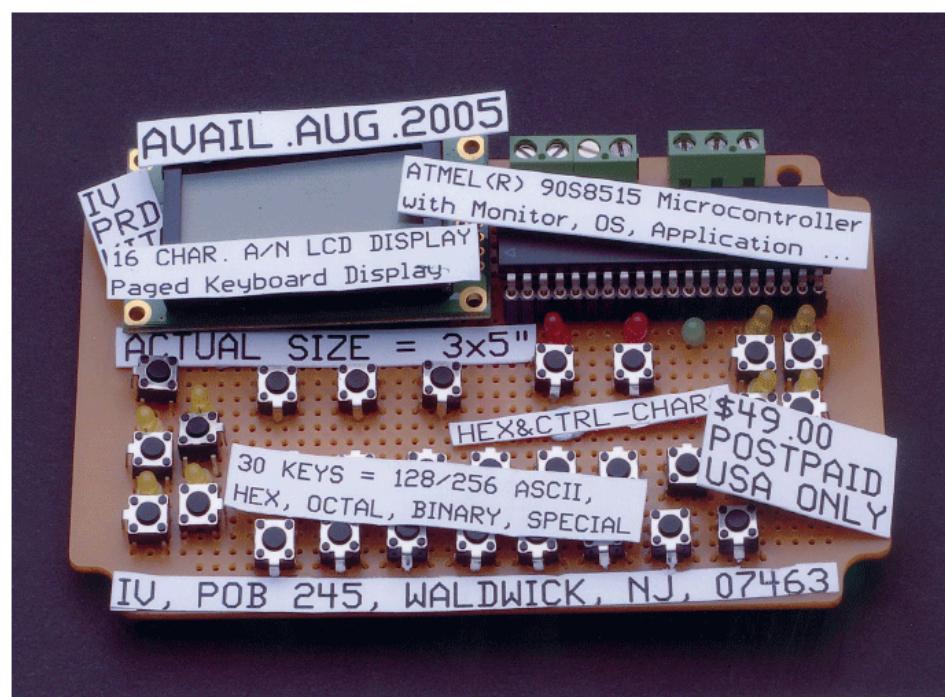
Patricia Silver, director of the Parkland Regional Library in Canada, ordered the installation of keystroke logging software on the computer of an employee whose productivity was questioned. When the employee discovered that he had been monitored, he lodged a complaint with Alberta's information and privacy commissioner.

In a decision released last week, Commissioner Frank Work ruled that the library collected personal information about the employee in contravention of the Freedom of Information and Protection Privacy Act.

The employee, who was not named, worked as a computer technician for six months in 2004. Ms. Silver said it was a job where productivity was hard to measure.

"We thought that using an objective check through the computer would be the most fair and objective way to do that," she said.

Ms. Silver disputed Mr. Work's finding that the library collected personal information on the employee, saying managers never looked at any of the computer files that were logged. She said she believed the keystroke logging would be allowed under a clause in the act that permits collection of information that is necessary for an operating program or activity of a public body.



Advanced Techniques for Design Engineers

# The Design Cycle

## Focus on the FLASH (Atmel AT49LV1025)

Integrating large FLASH and SRAM into microcontroller designs has become a must-know technique with the advent of microcontroller-based LAN devices. Sometimes an EEPROM just isn't enough to hold all of those web pages you want to serve from your little PIC-based or AVR-based web server. If you're collecting data, a large FLASH part is nice in that you can store away those accumulated readings and retrieve them intact, even if the batteries go bye-bye on your microcontroller-based data collection device.

A large SRAM device comes in handy when you need to temporarily store and process large arrays of data. For instance, you can build a

number of maximum size Ethernet frames in a large SRAM buffer and call upon them to be sent at will.

This spin of "Design Cycle" will focus on the Atmel AT49LV1025 FLASH IC and how to use it with a PIC. When you're finished reading this column, you'll know how to tie an Atmel AT49LV1025 FLASH IC to a PIC and code an AT49LV1025 driver. The AT49LV1025 interface knowledge you will gain here can also be easily applied to AVR microcontrollers.

I coded the AT49LV1025 driver for this column using C and the HI-TECH PICC-18 C compiler. However, that's not a show stopper. The C code I'll provide can easily be ported to any PIC or AVR BASIC language, as well. That's

the beauty of C. Let's begin by taking a walk around the AT49LV1025.

### The AT49LV1025

The AT49LV1025 is a 3V read/write FLASH IC that does not require any additional high voltages for programming the FLASH memory cells it houses. The AT49LV1025 is designed to be programmed, erased, and read while in-system.

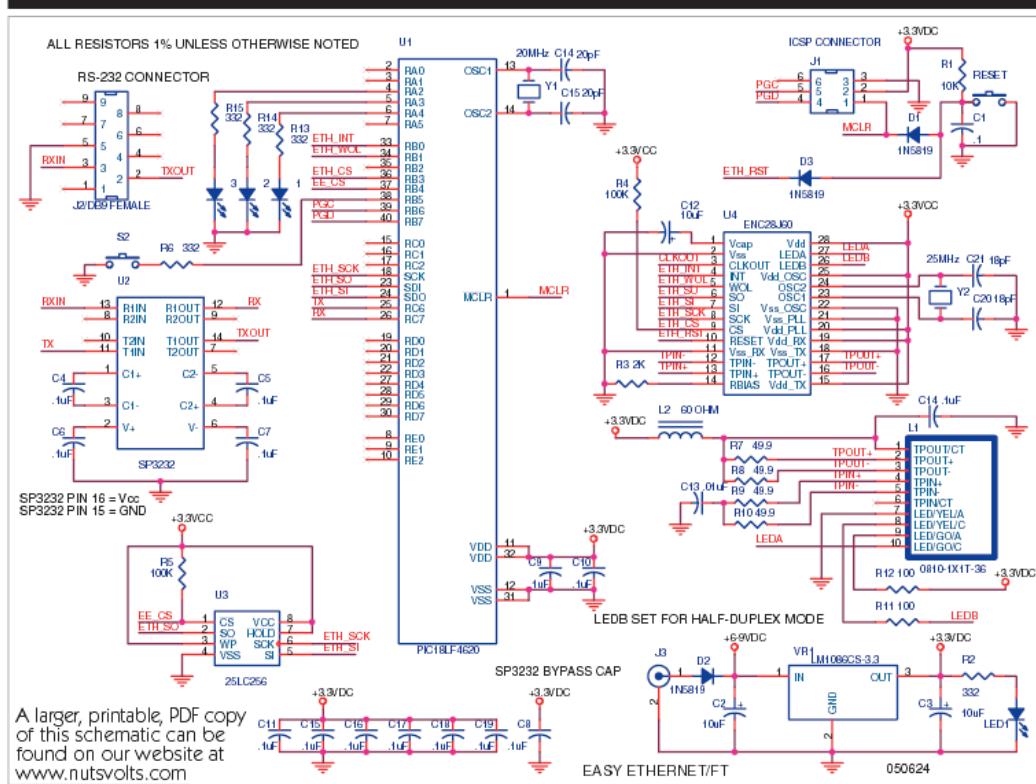
Logically, the AT49LV1025 is an EPROM that doesn't have to be removed from the system circuitry to erase and reprogram. The read access time of the AT49LV1025 ranges from 55nS to 90nS, depending on the grade of part you design into your project. I have selected the 90ns AT49LV1025 for this application.

The AT49LV1025 is the 44-pin PLCC-packaged first cousin of the AT49LV1024, which is housed in a 40-pin SMT VSOP package. The only difference in the AT49LV1025 and the AT49LV1024 is their packaging.

Erasing and programming the AT49LV1025 is accomplished using commands issued by the microcontroller that is in charge. An AT49LV1025 word write cycle is nominally 20 $\mu$ s long. The end of a program cycle can be sensed using one of two end-of-cycle features of the AT49LV1025, Not-Data Polling or Toggle Bit sensing.

If writing delay loops is your thing, you can also just kill 20 $\mu$ s between write operations. To use Not-Data Polling, the programmer

**Figure 1.** No rocket science here. This is a typical PIC microcontroller layout complete with ICSP programming/debugging port, serial port, and power supply. The AT49LV1025 is wired in according to the rules of the PIC's Extended Memory Interface.



issues a write command and immediately reads the address that was just written to. If the program cycle is in process, a complement of the seventh data bit of the data written to the location being read will appear on the AT49LV1025's I/O7 pin.

The complement of the seventh bit of data is where the "Not" in Not-Data comes from. Once the program cycle completes, 16 bits of true data can be read from the just-programmed location and the "Not" bit on I/O7 reads as the true value of bit 7.

The Toggle Bit sensing technique alternates pin I/O6 between a logical high and a logical low (1 or 0) while the program cycle is in process. When the program cycle completes, the I/O6 pin ceases to toggle and valid data will appear on the AT49LV1025's data I/O pins. The AT49LV1025 firmware written for this "Design Cycle" run will use the Not-Data Polling technique to determine the end of a program cycle.

The AT49LV1025 is a one-megabit FLASH device arranged as 64K x 16. The 64K (0xFFFF) of memory space can be optionally allocated as 8K (0x0000-0x1FFF) of Boot Block memory with the remainder of the 64K space (0x2000-0xFFFF), called Main Memory, left to be used at the programmer's discretion for machine instructions or data storage. If you choose not to employ an 8K Boot Block, the entire 64K of AT49LV1025 memory space can be considered logically as Main Memory.

The 8K Boot Block area can be write protected, which allows the remaining 56K of Main Memory area to be updated without fear of overwriting the 8K Boot Block area. However, you can run with an unprotected Boot Block and still maintain a logical distinction between the Boot Block and the Main Memory.

Two FLASH erase commands make this possible. The Chip Erase command initiates an erase of the entire 64K memory area, while the Main Memory Erase command only erases the Main Memory area beginning at address 0x2000. AT49LV1025 memory areas are programmed one

word at a time and have a minimum endurance of 10,000 program cycles.

There's one caveat to using a protected Boot Block. When you invoke what is termed Boot Block Programming Lockout via the Boot Block Lockout command, the Boot Block area can never be erased or reprogrammed again. This is done purposely to provide a high level of security for the code contained within the 8K of Boot Block memory.

Logically, accessing the AT49LV1025 is much like accessing an EPROM in that there are no special control lines to deal with. There are 16 AT49LV1025 address lines (A0-A15), which provide access to the AT49LV1025's 64K of memory space.

Since the AT49LV1025 is a 16-bit device, the AT49LV1025 is fitted with 16 tri-state-capable, bi-directional data lines (I/O0-I/O15). An active-low Chip Enable (\*CE) pin coupled with an active-low Output Enable (\*OE)

pin and an active-low Write Enable (\*WE) pin are all the control lines needed to gain read/write access to the AT49LV1025's vast FLASH memory resources.

So far, the AT49LV1025 seems to be an easy way to add 64K x 16 of FLASH memory to a microcontroller-based system. Basically, if you've ever used an EPROM or an SRAM in a project, you can apply that knowledge to the use of an AT49LV1025.

Let's take a look at what it takes to weave the AT49LV1025 into a typical microcontroller design.

## Some FLASH-Based Microcontroller Hardware

An AT49LV1025-based project can be assembled from scratch using through-hole, point-to-point, or SMT wiring techniques. I always test production designs with prototype

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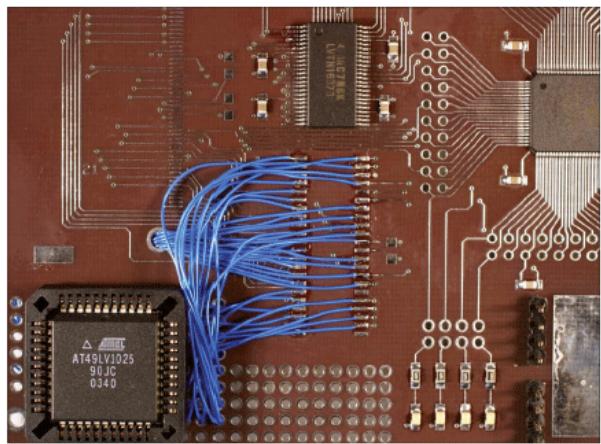
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**Figure 2.** Believe it or not, during the SOJ-to-PLCC wiring process, I only made a single wiring error! The 74LVTH16373 16-bit latch is just above the SOJ pad area and the PIC18LF8621 is in the upper right of the shot. Four LEDs and their associated current limiting resistors are also shown in this photo.

printed circuit boards (PCBs) before committing to a final production printed circuit board run. So, I always have a few fully-loaded prototype PCBs lying around that I can use for projects like this.

The prototype board I've chosen to use for the AT49LV1025 FLASH application is based on a 3.3-volt PIC18LF8621 running at 20 MHz. The wiring scheme of the prototype board I will use is shown graphically in Figure 1. There's nothing hardware here that you haven't seen before. The 74LVTH16373 is a three-volt, 16-bit transparent latch, which could easily be a pair of socketed 74LVTH573 octal transparent latches in your design.

The PIC18LF8621 is capable of switching the PortD, PortE, and PortJ I/O pins between EMI (External Memory Interface) and standard I/O modes. When the PIC18LF8621 is operating in Extended Microcontroller Mode, Table Read (TBLRD) and Table Write (TBLWR) instructions can be used to access bytes within the EMI address space (0x10000 to 0x1FFE for the PIC18LF8621).

The physics of the AT49LV1025 do not allow the use of the PIC18LF8621's Table Read/Write instruction set, as a byte within a word cannot be gleaned directly from the AT49LV1025's 16-bit data bus. However, I decided to wire in the

AT49LV1025 as if it could use the PIC18LF8621's Table Read/Write instruction set anyway.

Even when running in Extended Microcontroller Mode, I can switch off EMI and use standard I/O coding to access the AT49LV1025. Your application may require a mix of SRAM and FLASH. If it does, this is the way you want to wire in the AT49LV1025 as you can then choose your memory access method (EMI or standard I/O), depending on the memory device you are accessing at the time.

The PIC18LF8621-based three-volt prototype PCB I selected natively supports a 64K x 16 SRAM in a 44-pin SOJ package and its companion 16-bit 74LVTH16373 transparent latch. As you can see in Figure 2, I had just enough breadboard area to slip in a 44-pin PLCC socket to house the AT49LV1025. I wired the AT49LV1025's 44 PLCC pins to the corresponding 44-pin SOJ pads using wirewrap wire. That's about as exciting as the hardware gets. So, let's check out AT49LV1025 driver firmware.

## Accessing the AT49LV1025

The easiest way to understand the AT49LV1025 firmware is to take it function by function. So, let's begin with the least complex function: reading the AT49LV1025. The `read_flash` function writes the desired address to the 74LVTH16373 16-bit address latch and reads in the resulting data, which it returns to the `read` function's caller. The `read_flash` function begins by configuring PortD and PortE for output with the `TO_FLASH` macro.

Once the I/O ports are configured, the 16-bit address specified in the function call is converted into a pair of bytes that are sent to the

PortD/PortE port pair, which, when logically combined, make up a 16-bit I/O port. Raising the active-high ALE line from logical 0 to logical 1 opens the transparent latch and places the 16-bit address on the AT49LV1025's address pins.

After a small delay, the ALE pin is returned to a logical low state and the address data that was passed through the 16-bit latch is latched on the output pins of the 74LVTH16373 which, in turn, effectively latches the address onto the AT49LV1025's address pins.

At this point, the AT49LV1025 is addressed and ready for a read or write operation. The `FROM_FLASH` macro configures the PortD/PortE I/O port pair for input operation. To read a memory location, the AT49LV1025 `*CE` and `*OE` pins must be brought logically low while the AT49LV1025 `*WE` pin remains logically high. This is accomplished with the `clr_CE` and `clr_OE` macros.

Running at 20 MHz, the `NOP()` instruction expends 200nS of time. We only need 90nS of read access time, as we are using a 90ns AT49LV1025. So, a single `NOP()` instruction suffices for our read access time. Immediately following the 200nS of read access delay, the `read_flash` function inputs 16-bits of data in two eight-bit chunks and returns the `*CE` and `*OE` pins to their inactive logically high states. The two eight-bit chunks of data are then combined into a 16-bit data word by the `make16` macro and the incoming data word that was just read is returned to the caller.

Writing to a memory location within the AT49LV1025 is very similar to reading a word from the AT49LV1025. The `write_flash` function begins in the same manner as the `read_flash` function by parsing the 16-bit address into a pair of bytes and latching the address out onto the 74LVTH16373 latch outputs.

At this point, instead of preparing the PortD/PortE I/O port pair for input duty, the data word to be written is split into two bytes and placed on the PortD/PortE I/O port pair.

The PortD/PortE I/O port pair is in output mode thanks to the initial TO\_FLASH macro call. Again, the active-low AT49LV1025 \*CE pin must be taken to a logically low level.

However, instead of using the AT49LV1025 \*OE pin, the write\_flash function employs the PIC's active-low \*WRH pin, which is physically connected to the AT49LV1025's \*WE pin. WRH is the EMI term for WE. The write pulse is required to be a minimum of 70nS wide. The shortest time we can expend is 200nS with a NOP() instruction.

So, once again a single NOP() works for our write pulse width time, which ends when the AT49LV1025's \*CE and \*WE pins are returned to their inactive logically high state. For consistency, the PortD/PortE I/O port pair is always configured as input upon entry to any of the AT49LV1025 read/write functions.

A write operation changes 1s to 0s in the AT49LV1025 FLASH cells.

Since a 0 can't be reprogrammed to a 1, the entire block of FLASH memory must be erased before any reprogramming can occur.

If you are not implementing a protected Boot Block, the erase function with a chiperase argument can be used to erase the entire 64K FLASH memory area within the AT49LV1025. Six FLASH write cycles make up the Chip Erase command which, when issued, results in the erasure of the entire 64K of AT49LV1025 FLASH memory.

Each write cycle of the Chip Erase command must contain the particular address and data values as shown in the erase function listing. Note that we call upon the write\_flash function to perform the six Chip Erase command write cycles. The AT49LV1025 datasheet states that once the Chip Erase command is issued, the erase cycle will complete within 1.5 to 5 seconds.

To meet the erase cycle time criteria, a one-second interval timer is incorporated into the erase function. Take a look at the one-second Interval Timer Definitions area of Listing 1 (go to the *Nuts & Volts* website for Listing 1; [www.nutsvolts.com](http://www.nutsvolts.com)) and let's see what makes the one-second interval timer tick.

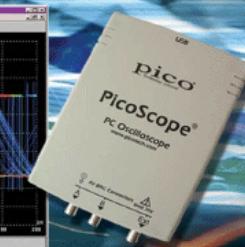
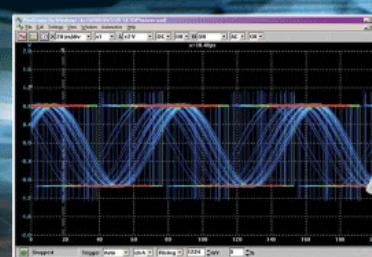
The CLOCK\_FREQ value is a given in that we know our PIC18LF8621 clock is based on a 20 MHz crystal. By selecting 100 ticks per second, we have specified a 10mS (.01 second) tick time without introducing fractions into the mix. Let's assume that we haven't decided on a prescaler or a prescaler value yet. Assigning a 1 to the TICK\_PRESCALE\_VALUE negates any multiplication factor that would be offered by the TICK\_PRESCALE\_VALUE variable.

Timer0 is configured as a 16-bit counter in that the T0CON register's sixth bit (T08BIT) is clear. T0CON is

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Erasing Boot Block and Main Memory..
Display Boot Block Memory
Data at 0x0000 = 0xFFFF
Data at 0x0001 = 0xFFFF
Data at 0x0002 = 0xFFFF
Display Main Memory
Data at 0x2000 = 0xFFFF
Data at 0x2001 = 0xFFFF
Data at 0x2002 = 0xFFFF
Writing 0x1234 to FLASH address 0x0000
Writing 0x1235 to FLASH address 0x0001
Writing 0x1236 to FLASH address 0x0002
Data at 0x0000 = 0x1234
Data at 0x0001 = 0x1235
Data at 0x0002 = 0x1236
Erasing Main Memory..
Data at 0x2000 = 0xFFFF
Data at 0x2001 = 0xFFFF
Data at 0x2002 = 0xFFFF
Writing 0x5678 to FLASH address 0x2000
Writing 0x5679 to FLASH address 0x2001
Writing 0x567A to FLASH address 0x2002
Display Boot Block Memory
Data at 0x0000 = 0x1234
Data at 0x0001 = 0x1235
Data at 0x0002 = 0x1236
Display Main Memory
Data at 0x2000 = 0x5678
Data at 0x2001 = 0x5679
Data at 0x2002 = 0x567A

```

**Figure 3.** Now you know enough about the AT49LV1025 to put the AT49LV1025 driver firmware to work in your project. This little demo shows how the data in the unprotected Boot Block is untouched by the Main Memory Erase command.

set to a value of 0x8F in the main module of Listing 1. Bit 3 of T0CON (PSA) is set, which means that the PIC18LF8621's prescaler is not in the Timer0 clock input loop.

Being a 16-bit counter, Timer0 will count from 0x0000 to 0xFFFF and roll over to 0x0000 continually. Every time Timer0 rolls over, we can choose to generate a timer overflow interrupt.

A tick in the one-second interval timer code occurs every time we

sense the interrupt caused by the Timer0 overflow. The idea here is to set Timer0 to roll over every 10mS or 100 times per second. We will poll the TMR0IF flag bit to determine when a Timer0 rollover, and thus a tick, has occurred.

A PIC instruction cycle consists of four oscillator clock periods. With a 20 MHz clock, each oscillator clock period is equal to the reciprocal of 20 MHz or 50nS. Thus, one instruction cycle time at 20 MHz is equal to 200nS. Timer0 increments on every instruction cycle time, or every 200nS.

To get the frequency associated with the 200nS clock period, we simply invert 200nS. That comes out to be 5 MHz, which is also the Timer0 clock frequency. In our AT49LV1025 code, CLOCK\_FREQ / 4 is just

another way of representing the Timer0 clock frequency of 5 MHz. Okay, we know that Timer0 is incrementing at five million counts per second. We want to know how many counts at 5 MHz it takes to consume 10mS. In other words, we want 1/100 of 5 MHz. We can multiply 5 MHz by .01 or simply divide 5 MHz by 100.

Since it's easier not to introduce fractions into our formula, we'll divide 5 MHz by our TICKS\_PER\_SECOND value of 100. That comes to a round 50,000 counts for every 10mS. We only want Timer0 to count 50,000 times before rolling over and causing a tick. So, we need to load Timer0 with our calculated TICK\_TIMER\_VALUE of 0x3CAF or 15,535 decimal (65,535 - 50,000) and let it start incrementing from there.

At every Timer0 rollover, we must reload the Timer0 registers with 0x3CAF to maintain our 10mS tick time. The 50,000-count value works because 50,000 is less than 65,535. If our calculated TICK\_TIMER\_VALUE was equal to or greater than 65,535, we would have to employ the services

of the prescaler. Let's assign a TICK\_PRESCALE\_VALUE of 256 and see what happens.

To use the Timer0 prescaler and assign a prescale value of 256, we must clear the PSA bit by setting T0CON's value to 0x87. The three least significant bits of T0CON specify the prescale value. With all of the prescaler bits set (0xX7), the prescale value is 1:256. We already know that the 10mS tick point is 50,000 counts.

Now, with the prescaler set for 1:256, each Timer0 count occurs at every 256th clock. To get our new prescaled TICK\_TIMER\_VALUE, we must divide our original 50,000 count by 256. The result — ignoring the fractional value — is 195. So, we load Timer0 with 65,535 - 195 decimal, or 65,340 decimal (0xFF3C).

The Timer0 prescaled 10mS value is radically different from the nonprescaled value, but it's still 10mS per tick in the end. I've inserted a global variable called global\_variable into the AT49LV1025 driver code to catch and hold the calculated TICK\_TIMER\_VALUE so you can see the calculated TICK\_TIMER\_VALUE result in an MPLAB debugging session.

Now that you know how the Timer0 tick time value is calculated, let's continue our look at the one-second interval code within the AT49LV1025 driver erase function. Following the six write cycles that form the Chip Erase command, Timer0 is loaded with the calculated TICK\_TIMER\_VALUE and the TMR0IF interrupt flag is reset. If a Timer0 rollover is detected, the TMR0IF flag bit is set and the Timer0 registers are reset to time the next 10mS interval.

Note that we aren't vectoring to a Timer0 interrupt service routine at every tick. We're simply using the Timer0 interrupt flag (TMR0IF) as a 10mS marker. When 100 ticks are accumulated, one second has passed. The elapsed seconds are collected by the SecCount variable, which is constantly checked against the value of the erase\_seconds variable entered at the calling of the erase function.

## Sources

Atmel Corporation  
AT49LV1025  
[www.atmel.com](http://www.atmel.com)

Microchip  
PIC18LF8621  
[www.microchip.com](http://www.microchip.com)

Texas Instruments  
74LVTH16373  
[www.ti.com](http://www.ti.com)

HI-TECH  
HI-TECH PICC-18 C compiler  
[www.htsoft.com](http://www.htsoft.com)

When SecCount is equal to erase\_seconds, the erase function terminates. At this point, the AT49LV1025 memory areas should all be erased and read as 0xFFFF.

The Main Memory Erase command is also issued by code within the erase function. The only difference between the Chip Erase and Main Memory Erase command functions is the data value in the sixth write cycle.

The data value is 0x0010 for the Chip\_Erase command and 0x0030 for the Main Memory Erase command. The Boot Lockout command requires 0x0040 in the data field of the sixth write cycle. I've used a C switch statement augmented by some erase function command definitions to determine which AT49LV1025 erase command to invoke.

We now know how to read and erase FLASH cells within the AT49LV1025. There's only one essential command left: Word Program.

Four write cycles are necessary to issue a Word Program command with the final write cycle specifying the actual address of the FLASH cell and the data to put into it. Immediately following the invocation of the Word Program command, a checkbyte is created. The checkbyte consists of the single true value of the seventh bit of the data specified in the word\_program function call followed by zeroes (binary X00000000).

The low byte of the data word is continually checked until the bit within the checkbyte matches the bit in the byte that is read from the AT49LV1025. That's all there is to it!

## Proof of the Pudding

Okay, we have everything we need as far as firmware is concerned to read, write, and erase the AT49LV1025. I put together some simple display memory and write memory functions using the AT49LV1025 read/write/erase firmware modules we discussed earlier.

Basically, the display memory function reads a number of words from the AT49LV1025 and sends the data

read out to the prototype printed circuit board's serial port. Conversely, the write memory function writes a number of words to the AT49LV1025. The read memory function automatically increments the address after each read cycle and the write memory function increments the value of the data word it is writing after each write cycle.

The idea of this little demo pro-

gram is to show you how the erase functions work for the Boot Block and Main Memory while certifying that our basic AT49LV1025 FLASH read and write functions perform as advertised. Hopefully, you should be familiar enough with the AT49LV1025 firmware to associate what you see in Figure 3 with the AT49LV1025 code in Listing 1. **NV**

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# Personal Robotics

## Hey, Mikey Likes It! A Review on the Hexcrawler HDATS

**B**uilding a Crustcrawler robot is like owning a luxury automobile. Everything about a luxury automobile is about being "a cut above the rest." That is what a Crustcrawler is all about. It is a robot building experience. Every step of the way was sublime, every nuance of the build was exquisite. If everything I did went as flawlessly, I would be the king of the world.

Some time ago, I was fortunate enough to build one of their "2 x 6" Hexcrawlers. I found that experience to be wonderful, but my time spent on the Hexcrawler HDATS was blissful. The thing practically built itself.

I was amazed when I opened up the box to find how much stuff was in there. Dozens of stamped,

bent, brushed, and anodized parts, hundreds of screws, washers and nuts, all divided into neat little logical bags, all labeled and ready to consume, all waiting for their Hitec HS-645MG servos to bring them to life. There was even an ample supply of extra parts, in their own little bags, labeled to indicate they were spare.

The details really become apparent when you notice that the aluminum pieces are brushed along their long axis. One piece by itself is nice, but the whole beast built up takes on a magnificent sheen. Screws are a mixture of black oxide and shiny zinc plated, all matched up nicely for aesthetics. Another nice detail is all the pre-made mounting slots for mounting your own hardware. This makes accessorizing your Hexcrawler a breeze.

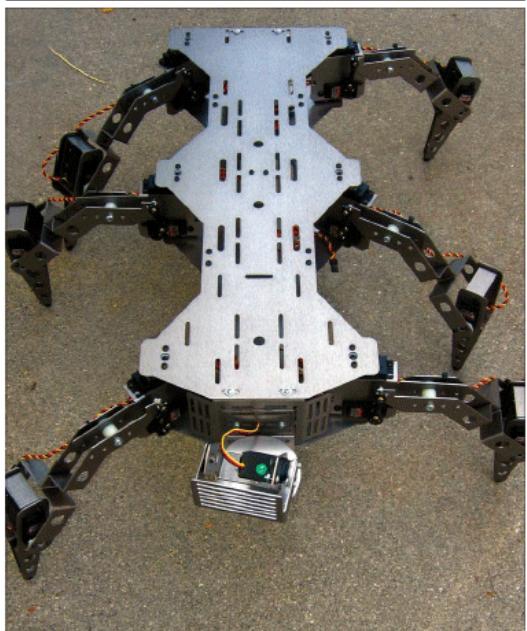
Another neat thing about it is the four different mounting points for the pivot of the knee. While it adds a bit of complexity for my inverse kinematics code, it allows you to trade between torque and travel. More power-

ful servos can use less torque advantage, and really move, or they can be set to more torque for better cargo capacity.

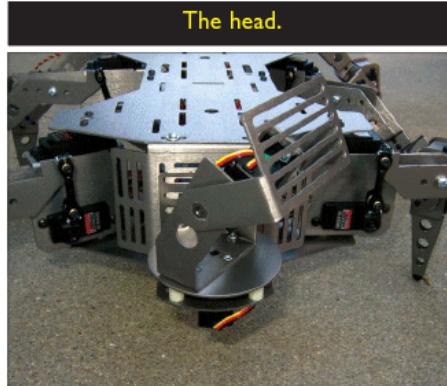
One thing that surprised me is how large this thing is. I mean it is like bigger than a badger. At something like 20" x 20" x 6", this thing is really massive. With the heavy duty, 107 oz-in servos, and the fulcrums for the legs set at maximum torque advantage, I may not have enough stuff to put on it. I do know that my little IsoPods and ServoPods will be lost on this thing. I guess I will be accessorizing it with a lot of gear. Here is a rundown of what I am considering:

- Poloyquest LiPoly batteries from [www.LightflightRC.com](http://www.LightflightRC.com) with battery monitor
- CMUcam2 from [www.SeattleRobotics.com](http://www.SeattleRobotics.com)
- Lassen GPS module from [www.Sparkfun.com](http://www.Sparkfun.com)
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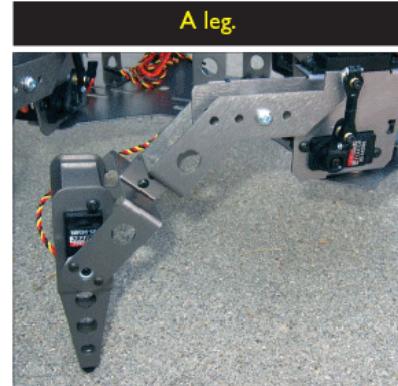
The Crustcrawler



The head.



A leg.



# Personal Robotics



Nice little linkages.



A plethora of parts.

- Sharp distance ranging sensors
- CUIstack force sensors for the feet, see [www.CUIstack.com](http://www.CUIstack.com)
- TAOS color sensors from [www.Parallax.com](http://www.Parallax.com)
- ServoPod for the brains from [www.newmicros.com](http://www.newmicros.com)
- Gambboy Advance as a graphical display
- S3 Pan/Tilt system from [www.Crustcrawler.com](http://www.Crustcrawler.com)

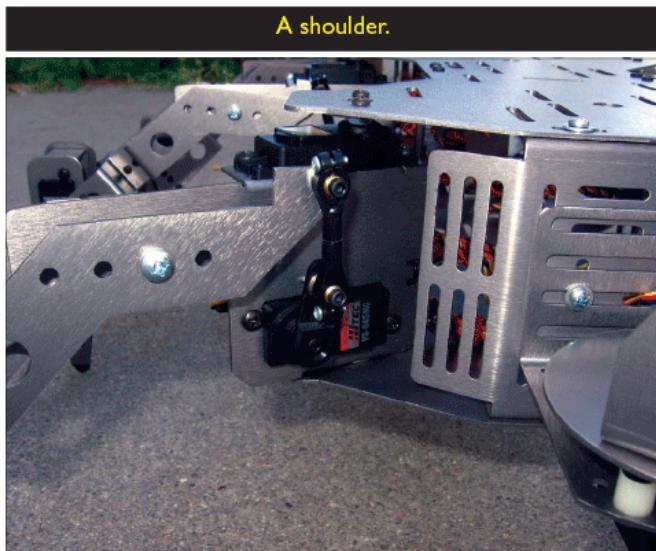
With all that empty space between components, maybe this is the time to play with distributed processing and some sort of bus architecture, one computer for each leg, and one for the head. Maybe I need to find a rider to control it, maybe wire up a lab specimen that won't offend PETA like a giant Madagascar hissing cockroach like what Garnet Hertz did ([www.conceptlab.com/control/](http://www.conceptlab.com/control/)) or maybe my pet snail. Whatever I can dream up, I know the thing will handle the mass.

The build was really straightforward, though I highly recommend looking

over the manual first, then proceeding to build. I managed to build mine up in about six hours, with only a Philips screwdriver, 3/32 Allen wrench, needle-nose pliers, flush cut diagonal cutters, 1/8" drill, and some tweezers.

There were no errors in the manual, though a couple of times I had to redo things, mostly due to my haste in building it. At times I wish the manual were a bit clearer, but when I approach something like this, I attack it in the most hurried of ways.

Overall, I couldn't be more pleased with the Hexcrawler HDATS. All the extra hardware was an unnecessary blessing. All the pieces fit together perfectly. With a minimal effort, everything came together flawlessly. This product gets a solid A+ rating from me. NV



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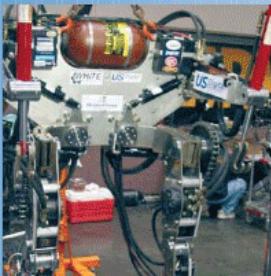
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# In The Trenches

Recognizing and Encouraging Good Ideas

**E**ngineers and engineering managers are always at the leading edge of technology. New ideas are potentially very valuable.

But, how do you know if a new idea is a good idea? What do you do when someone comes to you with a new idea? And, of course, how do you cultivate good ideas?

## Why it's Hard

Recognizing a good idea is not as common as it should be. In fact, it's often a very difficult thing to do. There are several reasons. The first is that new ideas are — by necessity — unconventional. If the idea followed convention, it wouldn't be new. People like the status quo. So, anything that changes that, makes them uneasy. Engineers are people, too. (Although there are some who will disagree.) So, it's first nature to push the new idea aside. Clearly, that's just as wrong as vigorously pursuing every new idea that comes your way. Thus, the first thing to do when someone comes to you with a new idea is to listen and evaluate objectively.

Of course, this is work and it takes time. If Bob comes into your office five minutes before you have to go to a meeting and says "I've got this great idea." Don't say, "You've got five minutes." Instead schedule 30 to 60 minutes (perhaps lunch) so you can actually listen to what he has to say.

If Bob says, "It'll only take five minutes," it's probably not a good idea, or a well thought-out one. Good ideas take effort to make

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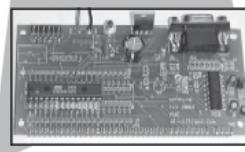
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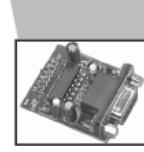
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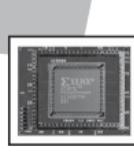
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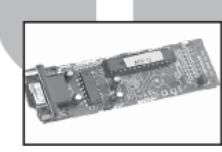
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them good. While the kernel of an idea may take only five minutes to explain, that in itself isn't necessarily good. The kernel's application and potential benefits and risks will take more than five minutes to discuss. If Bob can't address these points, he hasn't done his homework.

New ideas involve new risks. Again, it's human nature to accept familiar risks and avoid unfamiliar ones. Another word for this is experience. We all know how valuable experience is. If you're a hardware engineer, you'll probably design an analog audio filter because of your experience. If you're a software engineer, your first choice will be a digital filter. It's rare that it will be reversed unless there is significant pressure applied (for whatever reason). It's human nature to overestimate new risks while underestimating old risks.

Finally, new ideas require new words and thoughts. It's often very difficult to verbalize these things simply. Worse, Bob may not have good verbal communication skills.

So, getting his idea across may take considerable effort from both parties. Sometimes, it is simply impossible to bridge that verbal chasm.

### What Makes an Idea Good

Fundamentally, a good idea solves a problem. Sometimes the problem is obvious. Sometimes people don't even know that there is a problem.

For example, what problem did wireless transmission (or "radio") solve? At the time, many people felt that the telegraph was just fine. Ideas that solve problems that are not obvious are the hardest to

evaluate.

Of course, there are many types of "solutions." They can range from physical to financial to social. Good ideas have benefits that outweigh the costs. "Well, duh! That's pretty obvious," you say. The not-so-obvious problem is that quantifying the benefits and costs is not an easy thing to do.

This is especially true for novel ideas. The costs of developing "radio" were significant. The benefits, at the time, were not very clear. Radio range was much less than the telegraph and radio was much more complicated. Additionally, everyone could receive radio with the proper equipment. So, any message sent by radio was not very private. Not like the telegraph at all.

In the long run, new ideas will generally be cost-effective. That is why there is so much academic and industrial funding for theoretical

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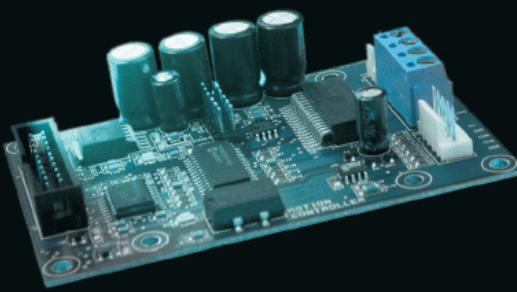
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research.

However, when someone comes to you about their idea, you don't have the luxury of waiting years or decades to recover the developmental costs. You will have to examine the idea from the short term point-of-view.

## Be Formal

I have found that a formal evaluation procedure of a new idea is very useful. Formal doesn't have to be intimidating. In fact, a properly designed formal evaluation can be much less stressful than an informal one. But this means up-front work for both parties.

First, you should publish a checklist of those topics that the new idea should address. For example: "What are the benefits of the idea? Be as specific as you can." What are the risks? How is the idea to be implemented? Are there similar ideas in use now? How long/how much will it take to develop? You might also place limits. It can't cost more than a certain amount to develop. It must be profitable within a specified period of time.

These topics are important to Bob because he probably hasn't thought about them. He's been focused on his great new idea, not on business. By having him examine his idea from a business perspective, he can get a better understanding of what is important to the company.

Additionally, he will have the time to think about and develop discussion points that are company-oriented. He'll know what to expect in the meeting. That's helpful to him. It's always easier to go into a meeting knowing what questions will be asked.

Have Bob write a paper to present and discuss at the evaluation meeting. This does several things. It forces Bob to organize his thoughts. It's often the case that someone thinks they understand something until they start writing it down. Only

then do the gaps in logic and improper reasoning become visible.

Additionally, new ideas are not born fully formed. They can be just a shadow or outline of a practical concept. They need to grow and evolve. Writing about an idea puts substance into the shadow. Bob has to think about his writing, as well as his idea. It also shows that you are

taking Bob seriously.

Allow Bob to bring an associate or two. This provides two benefits. The first is that Bob will feel more comfortable with a friend. It will be easier and less stressful. The second point is that the friend may be able to help Bob on difficult points. Having a different person explain a concept can be very useful.

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After all, the point of the meeting is to understand what Bob is proposing.

A formal evaluation (in writing) should be the result of this meeting. Hopefully, the evaluation should be presented to Bob within a week or so. It doesn't have to be long, perhaps a page or so. If the idea is accepted, you will want to lay out a preliminary

budget and schedule in the evaluation. There may be special requirements or situations that need to be defined, as well as limitations and expectations. Clearly, there will be ongoing meetings and progress reports. But, this is great news for Bob.

If the evaluation is negative, it is critically important to be specific.

Precisely, why isn't the proposal a good idea? This should be spelled out. Perhaps it costs too much or will take too long to develop. Maybe, it's unethical or violates copyright or patent laws. Possibly you disagree with Bob's assessment of profitability. Whatever the reason, state it. It is certainly nice to couch it in pleasant terms, but tell the truth.

There are two fundamental reasons for this. The first is your own credibility. If you just blow-off the idea, you will not get many more. Subordinates will think that the evaluation is just some arbitrary bureaucratic procedure. The second point is that your objection(s) may be answerable. Bob might be able to overcome the weakness in his idea if he is given the direction and opportunity to do so.

Of course, this means that you must be truly willing to reconsider the idea if the stated objections have been overcome. If an idea is too far removed from the company's core interests and will never be acceptable, this should be stated as well.

Note that I have not discussed any technical aspects of the idea. This is because it is assumed that Bob — an engineer — will have a good grasp of what is possible and practical. Most ideas, especially those created by engineers, are technically feasible. Although, sometimes a person's imagination exceeds his capabilities.

## Corporate Fears

It always seems to be the case that upper-management and executives fear all the time "wasted" on evaluating ideas. They're afraid that Bob will re-submit his idea again and again. They're afraid that "important" work will be delayed. These are silly fears.

First, an idea is a very personal thing. Few people enjoy having their visions rejected. It's very unlikely that anyone will choose to endure that

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over and over again. This is especially true if the evaluation was honest to begin with.

Secondly, it's important to cultivate good ideas. The company was founded on someone's good idea to begin with. Simply, good ideas are profitable and bad ones aren't. Every company must grow and that can only be done with profitable, good ideas.

Then there is the corporate mindset. This is the notion that the people who make the decisions must be smarter than those who just "work." In my experience, this egocentric point-of-view is surprisingly common (unfortunately). What's more, these people are not aware of how counterproductive this is and are usually unwilling to consider anything else. "The important people have all the good ideas."

For some reason, these people cannot see that an employee, on his own time, has created an idea that he thinks will make the company (and himself, of course) lots of money. What's more, he is willing to share this with the company. All Bob is asking for is a fair hearing about his idea. Not encouraging this behavior is simply a silly thing to do.

## Rewards for Ideas

Suppose Bob's new idea provides a \$1,000,000.00 yearly increase in product sales with a net profit of \$100,000.00 to the company. The company gives Bob a \$10,000.00 bonus. Once.

Do you think Bob is happy knowing that the company owners get \$90,000.00 this year and \$100,000.00 every year thereafter while he gets a one-time bonus of \$10,000.00? Would you be happy? Do you think Bob will ever provide another idea to the company? Or will Bob take a job at a different company where his ideas are worth more?

Management sometimes seems to think that people are stupid.

AUGUST 2005

They think that they are giving away \$10,000.00. They fail to realize that it is Bob who is really giving them \$100,000.00 every year. So, instead of rewarding Bob with a meaningful reward, they make Bob feel that he is being taken advantage of. And, of course, he is correct.

A proper reward would be some-

thing like 50% of the savings for the first year and 10% thereafter (or for some specified number of years). This will encourage Bob and others like him to provide the company with profit-making ideas. It's critically important to realize that Bob is the source of the \$100,000.00 yearly profit. He is the one who decided to give the company his idea. It's up

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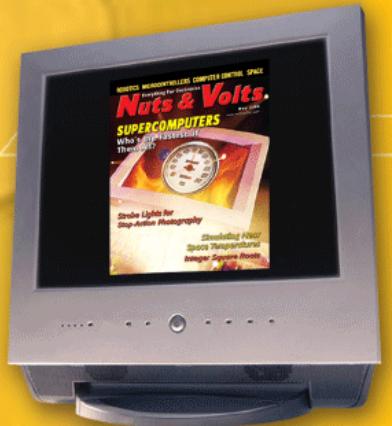
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## In The Trenches

to management to ensure that he will repeat his behavior the next time.

It also makes sense to reward people for all new ideas. Even for those that are not accepted. This is because Bob put forth a significant effort in creating his idea and writing it down (for the evaluation). Additionally, he places himself at some risk of embarrassment and/or ridicule.

Obviously, the evaluation should always be handled professionally. But, Bob's idea is a very personal thing and he is vulnerable. He knows that new ideas are often laughed at.

So, even if the idea can never be used by the company, give him \$100.00 for his effort and courage. He will appreciate it and will be all the more willing to submit more ideas. And, let's be practical. Where else can you get new ideas for \$100.00 each? eBay doesn't auction them.

Note. Again, some executives fear that Bob will take advantage of the situation by simply submitting idea after idea. This is not a reasonable fear. If your checklist is properly designed, he can't repeat the idea. If the evaluation is accurate, he will be forced to do considerable work to make the idea suitable for re-submission.

Naturally, Bob should not use company time to work on his ideas. So, the \$100.00 is a reward for work in excess of his regular job duties. Again, this is a great bargain for the company.

### The Suggestion Box

The suggestion box is arguably the worst idea for collecting good ideas ever employed.

At its best, it's just a morale boost for the employees. The box gets suggestions like: "How about putting a candy machine in the break room?" Or, "Let's go to a four-day work week."

Basically, it's just a feedback mechanism to management. If the

feedback isn't acted upon, then the box is perceived as another failed management tool that illustrates how out of touch management really is.

You will not find suggestions like: "Improving throughput by applying ergonomics to the production process." But these are exactly the ideas that the company needs. These are the ideas that can save the company huge amounts of money. How much profit will a candy machine make?

### Recognizing Good Ideas (Peer-to-Peer)

When a co-worker comes to you about an idea, you can't expect him to put it in writing. Rather, it should be a sit-down discussion. Be sure you have a block of time (usually an hour is adequate.) Sometimes lunch is a good idea. Always remember that ideas are fragile, personal things.

Even if it's a perpetual motion machine, take it seriously. This person has come to you for your comments, so be gracious. Peer-to-peer discussions will usually concentrate on the technical aspects that both people are familiar and comfortable with.

A good idea is well thought-out with attention to detail. So, listen carefully. If something doesn't make sense, ask for clarification. (Say, "I don't understand that part." Not, "That part doesn't make sense.") If the explanation does clarify the point, that's good. If not, it's bad because either the point is not well-understood or it's poorly verbalized.

Are the implications (also called secondary effects) understood? Suppose the design calls for the use of mercury. That's a heavy metal and may soon be banned in Europe and perhaps in the USA. Has he considered this? If not, is there a different approach that can work?

What specific problem does it solve? Some ideas are very intriguing, but have little application. Ideas

that have the potential for wide application are valuable. Is the idea for new technology, saving money, or social application? There are many different things to consider. Creating a pill that makes everyone the same size is a new technology. It saves money by allowing manufacturers to make only one size of clothing. And it clearly has a social application. But, what problem does it solve? It suggests that the problem is that people are of different sizes.

On the other hand, what about creating a cloth than can be stretched and then easily size-fixed-to-fit at the store. This does solve the problems of inventory and manufacturing multiple sizes of clothing. Changing the clothing to fit the person seems like a much better solution than changing the person to fit the clothes.

## Recognizing Good Ideas (Worker to Boss)

As was noted before, a manager looks at broader, more non-technical aspects of the idea. Generally, the outlook is pragmatic. If the idea helps the business, it's good. Otherwise it's bad.

It's important for the worker to understand this. If the company makes CRTs, a cure for AIDS (a vastly important idea) will generate little interest. Not because the people don't think it's a good idea. More simply, the company doesn't have the mechanisms in place to exploit it. A good idea from the manager's perspective is one that fits the company.

Naturally, the idea must be understood well enough by the manager to evaluate. And, let's assume that this is the case.

Oftentimes, the source of the idea can help determine if it's a good one. If Bob, a good worker with lots of experience, says that he can improve production by building special test fixtures, the idea will be

readily accepted. However, if this is Bob's first job out of high school and he's only been working for two weeks, it will be much more difficult to accept. It doesn't mean that the idea is bad. It's just that the new hire has had no time to develop credibility.

## Recognizing Good Ideas (Non-technical to Technical)

I often have non-technical clients who want me to develop their idea into a product. Here, the criteria for being good are more general. Is the idea feasible? Is the idea practical? Is the idea potentially profitable?

Obviously, it's unrealistic for a non-technical person to address the technical aspects of his idea. It becomes the evaluator's responsibility to consider these.

This can turn into a difficult situation if the technical person isn't being compensated for the evaluation. This is because the technical person can easily become a "co-inventor" of the idea. If Bob comes to you with a nub of an idea and you show him how to build it, you have

helped to turn the idea into a product. What do you do if Bob then goes to someone else to build and market the idea and makes millions of dollars?

Conversely, suppose Bob takes your input and makes a faulty product. He gets sued. And so do you, because you were the brains behind the design.

Both of these scenarios are rare, but they are possible. The important thing to remember is that you are likely to become "partners" with Bob in some fashion. The question then becomes: Is it a good idea to work with Bob? Rather than: Does Bob have a good idea?

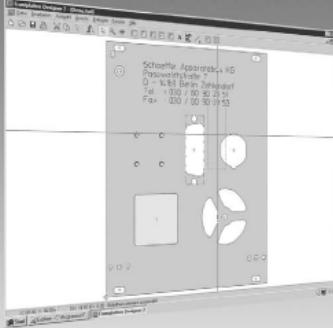
## Conclusion

Ideas, like beauty, are in the eye of the beholder. Different people will evaluate the same idea in different ways and come to different conclusions.

Fostering good ideas requires a true effort by management. And, because businesses must grow and evolve to stay competitive in today's business environment, good ideas are the life-blood of the company. **NV**

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# TETSUJIN 2005

**T**etsujin 2005 — originally scheduled for October 6-9 at RoboNexus — has been postponed. The registration deadline passed on June 13th, and there were not enough entries to hold the competition on the scheduled date.

We plan to reschedule the event sometime after the first of the year at a different venue. Individuals and teams interested in competing should drop us an email to let us know, so we can plan to go ahead and set a new date. The entry deadline will remain open for now. Don't send money or the entry form yet, just email to let us know you are interested in competing and we'll keep you posted on what to do next and when to do it.

Hey, look on the bright side, not only do you *STILL* have time to enter, you have even *MORE* time to design and build your exosuit! So, there's no excuse now *NOT* to compete! This is a hard competition and certainly one worth participating in. If it were easy, everyone would be doing it. This is your chance to stand apart from the crowd and flex your engineering and bot-building muscles. So, hook up with your friends, fellow engineers, classmates, geeksquad, gearheads, whoever, and form a team. No need to go it alone!

If you haven't already done so, check out the new rule set and event changes and start scribbling out your preliminary design. There's no time to lose! [Send an email to tetsujin@servomagazine.com](mailto:tetsujin@servomagazine.com) with your name and email address and we'll make sure you get all the latest info and news.

## **CHALLENGE 1:**

**Weightlifting.** Ascend stairs in your suit to the lifting platform and lift a load of from 100 to 1,000 lbs\* from a squatting position to a height of at least 24 inches\*, return the load to the ground in a controlled manner, and descend the stairs. Stair-climbing may be unpowered. The winner is the competitor who lifts the most weight.

## **CHALLENGE 2:**

**Dexterity.** Stack nine concrete cylinders weighing about 70 pounds each in a 4-3-2 vertical arrangement, but don't knock them over as the pyramid grows! The winner is the competitor who arranges the cylinders in the shortest time.

## **CHALLENGE 3:**

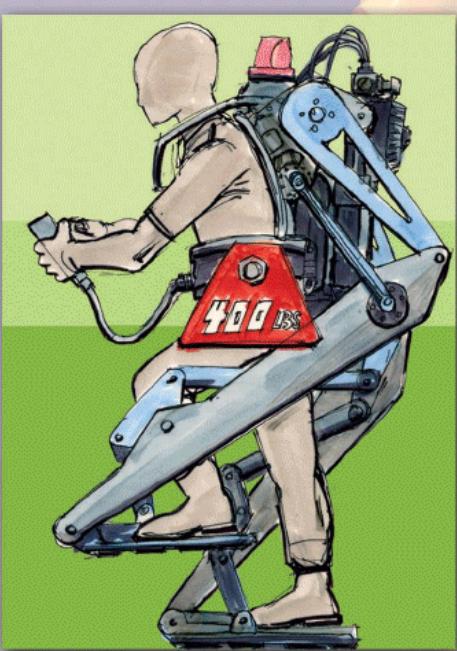
**Walking Race.** Walk the 100 foot\* long U-shaped challenge course, stepping over a small obstacle at the half-way point. The shortest time wins, with a time bonus being granted based on any auxillary load carried. Walking must be powered.

*The current rule set is available online at  
[www.servomagazine.com](http://www.servomagazine.com)*

*Questions can be directed to  
[tetsujin@servomagazine.com](mailto:tetsujin@servomagazine.com)*

**Don't wait, sign up for one, two,  
or all three challenges today!**

\*Specifics of the competition are in a tentative state and may be subject to change.



# Tech Forum

## QUESTIONS

I do telephone interviews (and have permission of the other party to record them). I need a phone patch circuit for a cell phone to get audio out at standard audio mixer levels that I can record via a laptop/computer sound card or cassette. Since the audio transmit and receive are separate with cell phones, the signals do not need to be mixed. I can run them separately to the right and left channels and mix them later.

The phone patch must plug into a Motorola T-2260 cell phone headset jack (standard 2.5-mm, three-conductor phone jack). The three

conductors are transmit, receive, and common ground. I believe that phantom power is supplied to the transmit (mic), as well.

I've already tried making a simple circuit that de-coupled the DC with 0.1mF and then 0.01mF caps in series with the signal lines, but I had the problem of the mic audio cutting out after a few seconds. I even tried an audio transformer isolation to stop ground loops. I'm thinking that there is RF coming in over the lines. Any ideas?

**#0805I**

Clyde  
via Internet

How does the LNB on a satellite receiver dish work? I know that

This is a READER-TO-READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

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### ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of \$25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by email or we can not send payment.
- Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also,

indicate to that effect.

- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

### QUESTION INFO

#### To be considered

All questions should relate to one or more of the following:

- 1) Circuit Design
- 2) Electronic Theory
- 3) Problem Solving
- 4) Other Similar Topics

### Information/Restrictions

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

### Helpful Hints

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.

LNB stands for "Low Noise Block" converter.

**#08052**

Sam Graumann  
Canon City, CO

I need to assemble a device which will record time-of-day in 24-hour format for events, as follows: a person sees an event, and pushes a button; he sees another event, and pushes another (or the same?) button. Later, he can retrieve the event times (capability for up to five events will be needed) and reset the device for use next time. It would be used in a 12-volt vehicle.

This could be as simple as tying together panel-mount clock modules that can be synced when setting the time. I know this can be done with a PIC and LCD display, but I know very little about them, and haven't been able to get off the ground with that approach.

**#08053**

Doug Johnson  
Kingsford, MI

## ANSWERS

### [#06052 - June 2005]

I'm using a PIC microcontroller to send data serially to my PC as sort of a data logger. I've been using hyperterminal to capture the info, but I need a time stamp on each incoming line to tell what time the data was taken. The time stamp should be system or actual time. I've tried using a serial port monitor program by Retisoft, but it uses its own stopwatch-style stamp, which doesn't mean a whole lot to me.

The easiest way to do this is to get a terminal emulator that supports scripts, such as Procomm Plus or NetTerm. You can then write a script that will detect an incoming pattern such as carriage return, linefeed, or other unique character (~) and insert the host computer's date and time into the data stream. You can even write automatic file swapping scripts that will create new capture files hourly, daily, or monthly.

The alternative would be to write

a simple datalogger program using C or even Basic to perform the data capture and date-time stamping.

I can help you with either option if you need assistance.

**Daryl Rictor**  
[circuithelp@yahoo.com](mailto:circuithelp@yahoo.com)

#### [#06055 - June 2005]

I have several refrigeration controllers for store produce coolers that I cannot find any programming documentation on and I'm hoping that someone can help.

I have a Cool/Delay Heat controller with dual temp probes. It's made by McLean Midwest. It has the part name Zero McLean on the wiring label. The part number is 10-1106-33 Rev: 0.

I would appreciate any information available – especially programming info.

A quick search with Google

shows that [Primeparts.net](http://www.primeparts.net/Products/mclean.shtml) is now handling many McLean Midwest products and parts at [www.primeparts.net/Products/mclean.shtml](http://www.primeparts.net/Products/mclean.shtml).

I don't see the part in question on their site, but maybe they have information on it. They can be contacted at the web address, or by email at [websales@primeparts.net](mailto:websales@primeparts.net) or by phone at (317) 257-6811.

**Carl Smith**  
**Dakota Dunes, SD**

#### [#07052 - July 2005]

I want to build a receiver circuit for a TV remote control. With the number of cheap "Universal" remote controls that are available, I'm hoping to be able to use one of these to control some of my electronics projects, without the need to construct the remote control itself. I'd think other experimenters could utilize such a receiver to add remote control capability to their robotic and other

electronic projects. I suppose I could try to salvage this circuit from an old TV or VCR, but since I'm not interested in having a tuner for TV signals, I was hoping for a simpler circuit. I'm also looking for a good book on how to troubleshoot these circuits in various TV and VCR applications.

**#1** IR remote controls use a pulsed signal that modulates a 38 kHz carrier. The detection circuit for those signals is very easy. You can purchase photodetectors that contain a filter at 38 kHz, so you are basically making them immune to other IR signals that are present in the environment.

For example, the Panasonic PNA4602 is one of these units that I have experimented with. It can be easily purchased at [solarbotics.com](http://solarbotics.com) at a cost of \$1.50 per unit when I just checked it. The documentation for this unit can be found at: <http://>



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## Tech Forum

[downloads.solarbotics.com/PDF/  
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Other IR receivers can be found at Electronics Goldmine [www.goldmine-elec-products.com](http://www.goldmine-elec-products.com)

You should also consult the January 2005 issue of SERVO Magazine ([www.servomagazine.com](http://www.servomagazine.com)) that contains an excellent article on decoding these signals, including a schematic.

Finally, the Parallax website has a very good "Stamp Weekend Application Kit" on infrared emitting diodes and 40 kHz infrared detectors that can be downloaded for free at [www.parallax.com/dl/docs/prod/compshop/irledndet.pdf](http://www.parallax.com/dl/docs/prod/compshop/irledndet.pdf)

Albert Lozano  
Edwardsville, PA

**#2** I have had great success using Athena class microcontrollers connected to a Vishay IR module. These microcontrollers have IR functions built in to read and send either Sony standard codes or raw data codes. Application notes can be found at [www.kronosrobotics.com/application.shtml](http://www.kronosrobotics.com/application.shtml). This page contains a few different examples of transmitters and receivers for different class microcontrollers, as well as a list of common Sony codes.

Christopher Coyle  
Unionville CT

**#3** The Innotech Systems IC1003 can decode most IR remote controls and provides a three-character ASCII code via a 9600 baud RS-232 signal. Here is a link to the Innotech website: [www.innotechsystems.com/ic1003.htm](http://www.innotechsystems.com/ic1003.htm)

Decoding an IR signal is relatively simple, and it can be done using a common microcontroller, such as a PIC or AVR.

Here is a link to a PIC-based project: [www.ida.net/users/oe1k/uirt/uirt.htm](http://www.ida.net/users/oe1k/uirt/uirt.htm) Here is a link to an AVR-based project: [www.unchanged.net/Electronics/RECS80/](http://www.unchanged.net/Electronics/RECS80/)

Daryl Rictor  
via the Internet

[#07054 - July 2005]

I have a number of IF transformers with no color-coded leads, and the primary and secondary have similar DC resistance. How can you determine the primary from the secondary, specifically the plate (collector) from the grid (base) leads?

The old IF transformers were designed to provide selectivity, not gain, so it probably does not matter which way you hook them up. If you have a signal generator and scope, feed a signal into one side and look at the output. The side producing gain (if any) will be the grid side. The frequency will either be 455 kHz or 10.7 mHz, although 262 kHz was also used.

Russell Kincaid  
Milford, NH

[#07055 - July 2005]

I'm using motor controllers with LMD18200 amplifiers in a robotics project, and the amplifiers literally blow up if the motor power is reversed! I'd like to find a simple way to protect from reverse polarity, but without an inline diode or rectifier because of the voltage drop associated with diodes, especially at higher currents when the motor really needs all the voltage it can get.

It would be nice to avoid old-fashioned fuses, as well.

A series MOSFET will be a low loss switch that will turn off when the voltage is reversed. Use a logic level device like Mouser part number 512-FQP20N06L (99 cents). Connect the gate to the positive input, the drain to the negative terminal of the motor controller, and the source to the negative of the battery. You won't need a heatsink in this application. The gate is rated 20 volts max, so if you are operating at 24 volts, a resistor and zener at the gate would be good insurance.

Russell Kincaid  
Milford, NH

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- Ceramic heating element for more accurate temp control
- Temp control knob in F(392° to 896°) & C(200° to 489°)
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- Separate heavy duty iron stand
- Replaceable iron/easy disconnect
- Extra tips etc. shown at web site

Item#

**CSI-STATION1** Rapid Heat Up!



**\$34.95!**

**Also Available w/Digital Display & MicroProcessor Controller**

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**\$49.95**

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**SMD Hot Tweezer Adaptor Fits CSI Stations 1 & 2, and also CSI906**

**\$29.00**

Item#  
**CSITWZ-STATION**



**In Business**



**NEW!**

**Bullet Style B/W Camera**

- Weather Proof
- Signal System: EIA
- Image Sensor: 1/3" SHARP CCD
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-305**

1-4:\$49.00 5+:\$46.00

Details at Web Site

> Miniature Cameras (Board, Bullet, Mini's, B/W, Color) & Security

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**Premier Repairing System w/Power Supply**

Microprocessor controlled design that provides stability and precision of temperature and airflow settings during the rework process. A full digital display of temperature and power source make everything clear to the user while the unit provides vast flexibility at the rework station with the built-in power supply that provides 15V and 2A of power. Hot air soldering and adjustment of temperature are controlled by a micro chip and sensor thus giving tremendous accuracy and reliability.

Item# **CSI768**Only  
**\$289.00!****NEW!**

- Iron Output Voltage: 24V / 35W
- Temperature Range: 100-480°C / 212-896°F
- DC Power Supply: 15V / 2A

Details at Web Site &gt; Soldering Equipment &amp; Supplies

**B&W Pinhole Bullet Camera w/ 1/3" CCD**

- Weather Resistant Housing
- Signal System: EIA
- Image Sensor: 1/3" CCD Bullet Hole
- Effective Pixels: 510 x 492
- Horizontal Resolution: 380TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-305CP**1-4:**\$49.00**  
5+:**\$46.00**

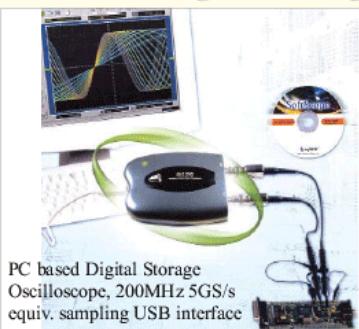
Details at Web Site

&gt; Miniature Cameras (Board, Bullet, Mini's, B/W, Color)

**4 Channel Digital Video Recorder**

- Signal System: NTSC
- Operation System: Embedded RTOS
- Video Input: BNC x 4
- Video Output: BNC x 1 / VCR OUT
- Resolution: NTSC 720x480/ NTSC 640x240
- HD Capacity: Max. Capacity up to 250GB
- Backup: VCR
- Alarm In/Out: 4 in NO/NC, 1 Out No

Details at Web Site &gt; Miniature Cameras (Board, Bullet, Mini's, B/W, Color) &amp; Security

Item #'s **VR-214 & VR-214-250G**Only  
**\$289.00 & \$429.00****NEW!****Digital Storage Oscilloscope Module**

PC based Digital Storage Oscilloscope, 200MHz 5GS/s equiv. sampling USB interface

Convert any PC with USB interface to a high performance Digital Storage Oscilloscope. This is a sophisticated PC based scope adaptor providing performance compatible to mid/high level stand alone products costing much more! Comes with two probes.

Details & Software  
Download at Web Site

&gt; Test Equipment &gt; Oscilloscopes/Outstanding Prices

Item# **200DSO** Only **\$899.00****LogicPort Logic Analyzer**

The LogicPort provides 34 sampled channels including two state-mode clock inputs. It connects to your PC's USB port for ultimate convenience and performance.

- 34 Channels
- 500MHz Timing mode sample rate
- 200MHz State mode sample rate
- Real-time Sample Compression
- Multi-level trigger
- +6V to -6V Adjustable Threshold

**\$369.00!**Item# **LOGICPORT**

Details at Web Site &gt; Test Equipment &gt; Logic Analyzers

**Plug-In Switching Power Supplies**

These 15W switching power supplies are an inexpensive way to power devices with robust regulated power and low ripple noise. The low-profile design allow you insert them into a power strip without losing any of the other plugs. Designed with an energy efficient switching technology, the Universal AC input works from 90-264VAC with no minimum load required and a 100% burn-in test to ensure they will perform as stated right out of the box. They come with a 1.8 meter output cord and a 5.5 x 2.1mm female plug. UL and cUL approved.

Item#	Description
3A-161WU05	5 Volts / 2.6 Amps
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3A-161WU09	9 Volts / 1.70 Amps
3A-161WU12	12 Volts / 1.25 Amps
3A-161WU18	18 Volts / 0.84 Amps
3A-161WU24	24 Volts / 0.63 Amps

Each	10+	25+	100+
<b>\$9.95</b>	<b>\$8.95</b>	<b>\$8.49</b>	<b>\$6.95</b>

**NEW!**

Details at Web Site &gt; Test Equipment &gt; Power Supplies

**SONY Super HAD CCD Color Weatherproof IR Camera**

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 480TV lines
- Min. Illumination: 0Lux

Item# **VC-827D** 1-4:**\$149.00** 5+:**\$139.00****SONY Super HAD CCD B/W Weatherproof IR Camera**

- Day & Night Auto Switch
- Signal System: EIA
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-317D** 1-4:**\$69.00** 5+:**\$65.00**

**SONY Super HAD CCD™ equipped camera's feature dramatically improved light sensitivity**

**SONY Super HAD CCD Color Camera**

- Weather Proof
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-805** 1-4:**\$69.00** 5+:**\$65.00**

Details at Web Site

&gt; Miniature Cameras (Board, Bullet, Mini's, B/W, Color)

**SONY Super HAD CCD Color Weatherproof IR Camera**

- Day & Night Auto Switch
- Signal System: NTSC
- Image Sensor: 1/4" SONY Super HAD CCD
- Horizontal Resolution: 420TV lines
- Min. Illumination: 0Lux

Item# **VC-819D**  
1-4:**\$89.00** 5+:**\$79.00****SONY Super HAD CCD Mini B/W Board Camera**

- Signal System: EIA
- Image Sensor: 1/3" SONY Super HAD CCD
- Horizontal Resolution: 420TV Lines
- Min. Illumination: .05Lux/F1.2

Item# **VC-103** 1-4:**\$33.00** 5+:**\$29.00**

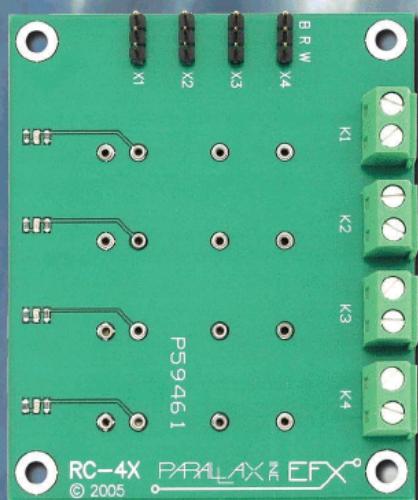
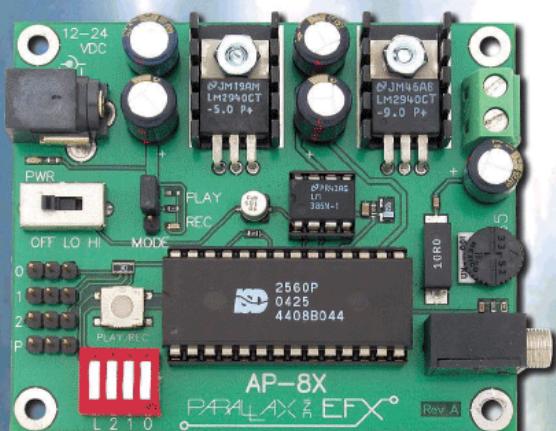
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**Prop-1 Controller (#31101 - \$34.95)** - The Prop-1 Controller is a single board solution that is perfectly suited for many haunt and prop applications. Built from the BASIC Stamp® 1 microcontroller, the Prop-1 offers eight I/O pins and is powered by either 12 or 24 VDC. It can control TTL outputs (5VDC), hobby servos, 12-24 VDC solenoids, low voltage lamps, and small DC motors. A three-position power switch allows the use of one power supply, or two isolated power supplies.

**AP-8X Sound Board (#31308 - \$49.95)** - The AP-8X audio player allows you to easily record and playback up to eight sounds totaling 60 seconds. These sounds may be recorded in any order and played back in any order. Playback can be controlled with a controller, or simple switches. Includes an on-board bi-level selectable amplifier and volume control, which changes volume from a loud gasp to a *blood-curdling scream!*

**RC-4X Relay Board (#31204 - \$24.95)** - Safely control 110-220 VAC loads with the popular Crydom D2W202 series of SSR. The RC-4X connects to the Prop-1 with three-pin cables to safely transmit low-voltage control signals to the SSRs. Small, bright LEDs indicate which loads are "hot."

*Available individually or as package deals in September 2005. Order online at [www.parallaxEFX.com](http://www.parallaxEFX.com) or call our Sales Department toll-free at 888-512-1024 (Monday-Friday, 7am-5pm, PT).*

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